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CONTENTS

	Page
Editor's Outlook	518
The Future of the Synthetic Organic Chemical Industry in America. Charles H. Herty	519
Observations on Teaching the History of Chemistry. Edgar F. Smith	533
Teaching Principles of Electrodeposition. W. Blum	556
Correlation of Lecture, Recitation and Laboratory Work in General Chemistry. C. A. Brautlecht	566
Application of the Electron Concept to Oxidation-Reduction Reactions in General Chemistry. Stuart R. Brinkley	576
Objectives in Teaching Chemistry. H. R. Smith	585
Chemistry and Science in Prehistoric America. James A. Branegan	588
Educating the Public in the Use of the Metric System. Harvey A. Neville	593
The New Assistant. A Metric Play. Alton L. Hall and the General Science Class of Bishop, California	600
Some Suggestions as to the Selection of a Laboratory Manual for High-School Chemistry. W. G. Bowers	605
Ballad of Ryerson. Edwin H. Lewis	610
Classroom Emanations	611
Chemical Digest:	
Abstracts	612

Note on the Sealing of Carius Bomb-Tubes
Some Recent Representations of the Periodicity of the Elements
The Training of Chemists in the University of Minnesota
The Care of Student Health
Anecdotes about Mysterious Explosions and Fires
The Possibilities of a "Burned Out" Electric Light Bulb in General Science
A Ninth Grade Course in General Science
The Use of Text Book and Syllabus Courses in General Science
Effect of Methods of Instruction upon Character
Research in the University of Virginia
How to Make a Chemical Flask Motor
Chemical Spelling Continued
Classification and Eligibility
The British Association of Chemists—The Title Chemist
A Simple Toepler Pump
Teaching Temperature Effects to Elementary Students
A New Acid-Resisting Material
Too Many German Chemists
Aspects of Practice-Teaching in the Preparation of Chemistry Teachers in a State Normal School
Research Problems Presented by the Petroleum Industry
Silicate of Soda and Soaps

Local Activities and Opportunities	618
Recent Books	621
A Few Minutes with the Business Manager	625
Just a Few Excerpts from Here and There	626

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EDITOR'S OUTLOOK

The third Colloid Symposium, reported elsewhere in this issue of The Journal, constitutes a striking and concrete illustration of the advance and expansion of the science of chemistry in general and colloid chemistry in particular.

The Colloid Symposiums have been, from the first, well-attended, productive and inspiring. This year's meeting was particularly notable from three standpoints:

1. The volume of attendance and the general enthusiasm displayed
2. The large number of papers offered for presentation
3. The high standard of scientific merit which prevailed among the papers presented.

As teachers of chemistry, we are unmistakably confronted with the fact that colloid chemistry has not only taken its place as one of the major branches of our science, but that its rapid and continuing development is already making it a fundamental one.

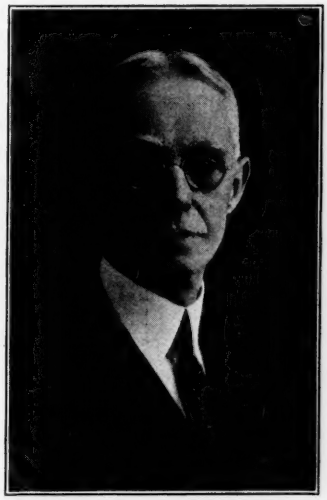
Even the specialist (in whatever branch of chemistry he may engage) is now forced to recognize the fact that his field includes innumerable phenomena of a colloidal nature and that the pursuit of his specialty necessitates at least a general knowledge of colloidal principles. To the general chemist, the situation is even more obvious.

We trust that the teachers of chemistry will not be the last to interpret the hand-writing on the wall.

THE FUTURE OF THE SYNTHETIC ORGANIC CHEMICAL INDUSTRY IN AMERICA*

CHARLES H. HERTY, PRESIDENT, SYNTHETIC ORGANIC CHEMICAL MANUFACTURERS ASSOCIATION, NEW YORK CITY

Progress in Coal-Tar Chemicals
Advances in Non-Coal-Tar Synthetics
Utilization of Corn Products
Lead Tetraethyl
Pyrotechnic Developments
New Medicinals
New Wealth from Petroleum
Scientific Advance Depends upon Research
New Type of Research Needed
Problems in Education
Competitive Conditions
Foreign Loans Endanger American Industry
Patents an Important Factor



DR. CHAS. H. HERTY

President, Synthetic Organic Chemical Manufacturers Assn. of the U. S., One, Madison Ave., New York City.

Realizing fully the many possibilities of error that confront the human prophet and conscious of no gift of clairvoyancy which would assure safe prediction, the title suggested by the Secretary of this Division, "The Future of the Synthetic Organic Chemical Industry in America," has been gladly accepted. No matter if the final picture varies in some details from such forecast, whether some shades prove brighter, some of a more subdued tone than are now expected, nevertheless the limning of that picture has been advanced so far within the past decade that none but the most confirmed pessimist can doubt its ultimate beauty. My duty today is to set before you the work that has been completed, and then to try to point out conditions and influences which may hasten or delay its progress. The metaphor fails here, however, for fortunately there is no real completion of this work, but an ever increasing field of useful service to humanity.

For the raw material of this industry we need have no concern. The full requirements for complete national needs and for a reasonable share of the world's export trade constitute but a small fraction of our annual output of coal, petroleum, corn, cotton and other products.

For facts as to development and present status we are fortunate in having available the carefully compiled Annual Census issued by the

* Paper read before the Division of Industrial and Engineering Chemistry, American Chemical Society, Baltimore, April 7, 1925.

U. S. Tariff Commission. For seven years, with the eighth soon to be issued, it has given detailed statistics on the domestic coal-tar chemical industry, and for the last three years has included also many products of non-coal-tar origin.

Strange to say this Annual Survey had its origin in a certain lack of confidence by Congress in the good faith or ability of American chemists and chemical manufacturers. In the Revenue Act of 1916, protection for the coal tar chemical industry was included, but if our industry was not producing sixty per cent of the value of domestic consumption at the expiration of five years, the President was directed to annul, by proclamation, the specific duties provided in the Act. It was to inform the President from year to year of the progress the industry was making toward that 60 per cent which led to the publication of these volumes, whose initial purpose was soon accomplished, but their great value to both Congress and the industry resulted in their continuance, we hope as a permanent policy of the Commission.

Progress in Coal-Tar Chemicals

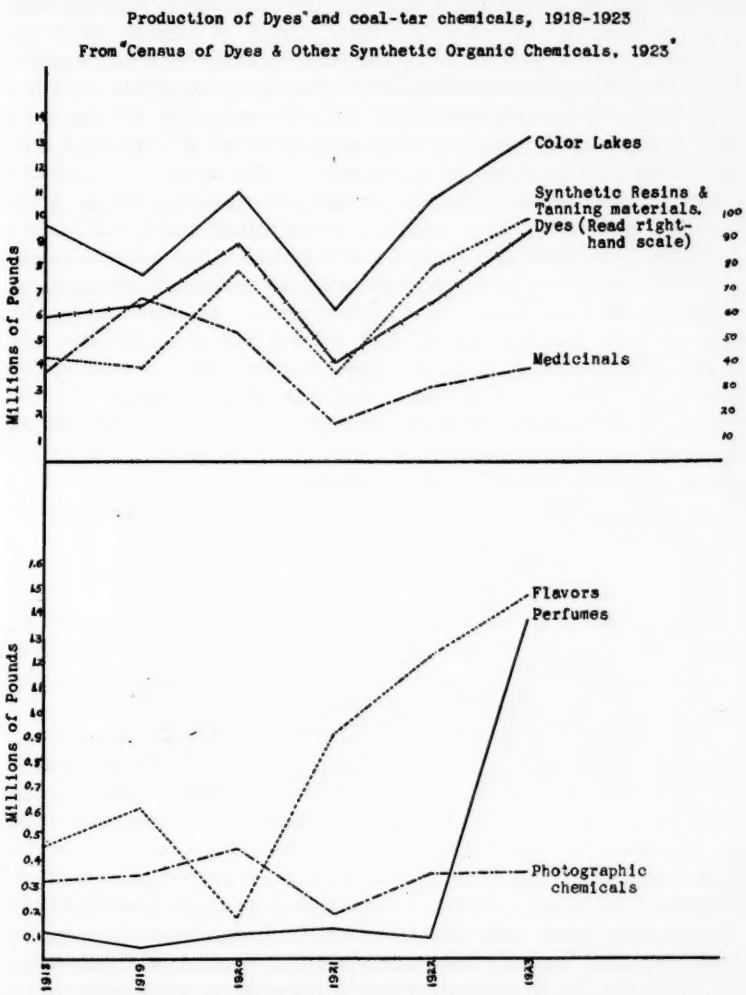
As to the development of the coal-tar chemicals, it is not my purpose to burden this paper with a mass of statistical data, for on Pages 7 and 8 of the latest published Census of the Commission (1923) there will be found a complete compilation of the tonnage production of the various groups of products for successive years beginning with 1918. The progress made in each of these groups is shown in the accompanying chart. From this figure and from the fact that the industry is now supplying more than 97% of domestic needs, it is evident, with the exception of a limited number of substances still to be brought on the market by American manufacturers, our industry has now reached the point where it is abundantly able to take care of all domestic needs. Furthermore, reports of the Census show that we are now manufacturing a considerable surplus of tonnage products for export, and as a matter of fact, knowledge of manufacturing methods has progressed so far that it would be a simple matter to double quickly the present tonnage of production.

The story of this amazing advance has been so often told that it is not necessary to repeat it here. The impetus already gained in the development of trained research workers and technical men, together with the infinite possibilities that still lie ahead in this field, makes certain that there will be no let-up in this advance.

Advances in Non-Coal-Tar Synthetics

I prefer rather to emphasize to you today the tremendous forward strides which have been made in the last decade in the field of synthetics of non-coal-tar origin, about which there is not so thorough a general

understanding. The flare of publicity has not attended these developments but they have been going forward steadily, and as they are assembled



into a unified picture they present a story fully as fascinating as that of the coal-tar products.

It is impossible to present in a paper such as this even a summarization of the multitude of new lines of development which have been steadily pressing forward. The mass of material overwhelms me. I can only

select certain striking lines and present them to you as an index of what may be hoped for.

In the field of the alcohols utilization of waste molasses from the sugar industry has given us not only a great supply of commercial alcohol, but through the brilliant work of a trained research staff new light has been thrown on the supposedly well-known fields of dehydration and esterification. Two illustrations will make clear the magnitude of this work: First, the average chemist who thinks of absolute alcohol in terms of a few gallons may be interested to know that one firm alone has a potential capacity of 10,000 gallons per day of absolute alcohol. Second, an interesting incident occurred recently where a certain paint manufacturer desired several hundred gallons of ethyl acetate. To secure so large a quantity of this material the paint manufacturer undertook quite a journey to interest the ester manufacturer in his program. He stated his problem fully, and felt confident that he had aroused interest. The ester manufacturer turned to his desk and handed the traveller a telegram just received. It was an order for sixteen tank cars of the material.

Through fermentation processes a considerable quantity of the corn crop of the Middle West is being transformed into butyl alcohol and acetone, which are finding greater and greater use as solvents.

Isopropyl alcohol, for so long a chemical of more or less academic interest, is now being marketed in large quantities.

Utilization of Corn Products

Perhaps two of the most interesting developments in recent years also utilize our great corn crop as raw material. From the hitherto waste corn-cobs there are now being marketed in commercial quantities furfural and a host of derivatives of furoic acid.

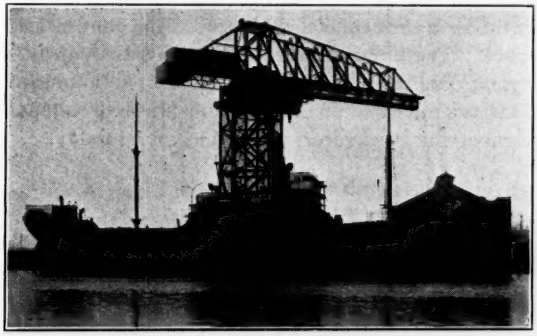
From the corn grain itself commercial glucose has been manufactured for many years, but because of the difficulties of crystallization and the presence of accompanying dextrines the field of its utilization has been somewhat circumscribed. A brilliant technical achievement now brings on the market in practically unlimited quantities a white, crystalline dextrose of 99.85% purity on a dry basis. The future of this remarkable product is unlimited. As approximately three parts must be used to obtain the same sweetening effect as two parts of cane sugar, it must necessarily sell at a more or less correspondingly lower price. However, it has on its side the well recognized advantage of ease of digestion. As we recall the acute sugar shortage during the recent war it is a comforting thought to feel that our nation is forever freed from such hardship in the future, for if any shortage should again occur, one of our greatest crops, corn, in the hands of chemists, can readily make good the shortage. Sooner or later I am confident that certain adverse features of our pure food laws

which now restrict its use, because at the time of their adoption no such products existed, will be so modified as to give to dextrose, chemically a true sugar and of such exceedingly high purity, its rightful place in the daily life of the nation.

Another interesting and unique industry is that of liquid hydrocyanic acid. It is difficult to realize that this industry on a large scale is only five years old, for it now makes available each year 3,000,000 pounds of this product. Prepared from cyanamid and sodium chloride with single phase electric current and subsequent treatment by sulfuric acid, it will be seen how readily available are still greater quantities of this material. The former difficulties of freight shipment of the material have been overcome and the product is now easily distributed in containers approved by the Interstate Commerce Commission.

Lead Tetraethyl

How short a time has elapsed since many of us were hurrying to the literature to get familiar with lead tetraethyl. For more than a half century this substance has slumbered in the literature of chemistry, and



THE BROMINE SHIP "ETHYL"

yet today, despite the many distressing difficulties that had to be overcome in gaining experience in manufacture, this product is being turned out in enormous quantities for the use of motorists. Of equal interest is the development in equal magnitude of the product hitherto of only limited uses, ethylene bromide. This development has upset the world bromine situation. Many wells are being sunk each month, new sources are being sought in various parts of the world, and most recent of all, a serious attempt is being made to carry on at sea in a floating factory the extraction of bromine from sea water. It leaves one gasping for breath as to what developments may be next ahead of us.

Among the organic acids of non-coal-tar origin, the manufacture of oxalic acid is destined to have an immediate and extensive increase, because of the recent action of the President in proclaiming, upon the recommendation of the Tariff Commission, additional customs duties upon this product.

The production of mucic acid from the western larch, interrupted in 1924, is again under way with large scale production.

Pyrotechnic Developments

A most interesting feature connected with these organic acids is the present trend of pyrotechnics. Hitherto inorganic salts which give an undesirable residue have been generally used. It has been found that with accompanying use of ammonium chlorate, salts of organic acids give much better results, leaving no residues, the metals volatilizing as chlorides. As an illustration of what may be expected, I am informed by an eminent expert in the field of pyrotechnics that 2% of strontium resinate in the mixture will give the same result as 70% of strontium nitrate. We can readily see what an important field is here opened to the Signal Service of the United States Army.

Experimentation in the field of accelerators in the vulcanization of rubber continues apace. The trend of the most recent developments in this line, where such great quantities of material are required, is toward synthetics of non-coal-tar origin. The guanidines and aldehyde amines stand out preëminent among the accelerators most widely used today.

New Medicinals

Among the medicinals tonnages comparable to those products above mentioned are not to be expected, but the value of those compounds to the health and happiness of our people makes the appearance of each striking new product a signal for rejoicing. The hypnotic—barbital, the local anesthetic—butyn, the valuable reagents against leprosy—the esters of chaulmoogra oil, are evidence of activities in the research laboratories of our medicinal manufacturers. It is a gratifying thought that as new compounds or hitherto little known compounds have their therapeutic value proved we now have abundant scientific skill to insure the manufacture in large quantities and in a high state of purity. How important this high state of purity may be is illustrated by the fact that perhaps the best curative known today for the so widely prevalent hookworm disease is found to be carbon tetrachloride, not the commercial carbon tetrachloride, however, but only that of the very highest purity.

An interesting new field has been recently opened in the work of one of our manufacturers starting with acetylene from calcium carbide as a raw material. Such products as ethylene oxide, ethylene chlorhydrin, ethylene

glycol, etc., are now available or can be quickly made available in enormous quantities, and open up new vistas of possibilities among synthetics of non-coal-tar origin. I am free to say that I had been accustomed to think of ethylene oxide as more or less of a laboratory curiosity, but my thoughts received a somewhat rude jar when I learned recently of a trial run in which a ton of this material was prepared.

In all of the advance during the past few years one feature has played an important role in the research which necessarily has preceded commercial manufacture, that is, the work of the Eastman laboratory in making available an ever increasing number of research chemicals. The latest list shows that the number has now exceeded 1900. I have purposely refrained from giving the names of individual manufacturers, but in this particular case I must make exception, for the origin of this work had no commercial thought. Mr. Eastman and his associates saw the need that must be filled if the research workers of America who were endeavoring to effect economic independence were in turn to be made independent in their own means for work. Facing for many years an assured financial loss, the work was vigorously pushed and in its development has commanded the scientific coöperation of a number of university laboratories and of industrial plants. Viewed from this angle it has been the means of bringing about a striking illustration of university and industrial coöperation with resultant good to all concerned. I can easily foresee greater possibilities in this development than its founders originally contemplated.

New Wealth from Petroleum

Thinking of our national resources of raw materials other than coal-tar for synthetic organic chemicals, the matter of our great national asset of petroleum naturally suggests itself. Here is presented a remarkable phenomenon, yet somewhat typical of the past history of our country. It is estimated that about nine billion dollars have been invested in the American petroleum industry. The raw material, crude oil, has in the past been subjected only to certain physical processes, chiefly fractional distillation, with a limited amount of purification by simple chemical methods, the resultant products being used chiefly for fuel, lighting and lubrication. Such chemical work as has been availed of in this field has been devoted largely to control of mechanical operations. The hurly-burly of oil exploitation seems to have practically excluded the research chemist, especially in the field of synthetic organic chemistry, and so this great mass of national wealth continues to be used almost totally for purposes which overlook the vast potential wealth hidden in the paraffin and olefin molecules. The industry could well devote a reasonable fraction of its income to fundamental research which will eventually result in the building up of products of far higher value to civilization. Recently, however,

there have been evidences of a new spirit of research striving to make itself articulate. It has been my good fortune to be thrown in slight contact with this movement, and I am violating no confidence in saying that within the past year a most able survey of the needs of research and the remarkable possibilities resulting therefrom has been canvassed by a committee of eleven of the most prominent scientists in this country, men whose names are household words with us and whose accomplishments show they are no idle dreamers. Their views and their findings have been put into definite shape. The realization of the great program prepared awaits now only concurrence in the importance of the work on the part of the financial leaders of the industry and the willingness on their part to set aside a small fraction of their investment annually to start this work in full force. The day may come when petroleum has become so diminished in volume that we will have passed on to other means for fuel, lighting and lubrication. After reading the comprehensive report which has been prepared, I cannot escape the conviction that the great leaders of our oil industry will soon have put on them the decision of determining whether they will go down in history as the despoilers of one of the nation's greatest assets or as benefactors who made available a greater source of national wealth than is now derived from petroleum.

Scientific Advance Depends upon Research

It has been estimated that, leaving out other factors and taking the success attributable to the application of scientific research as 100 per cent in the cases of the coal-tar chemical industry and the electrical industry, that proportion in the petroleum industry is less than 7 per cent. That is a serious indictment in these modern days of scientific advance. Let us all hope that those leaders of this great industry who can abundantly finance the great plan of research already mapped out, will take the time to give careful study to this most comprehensive report and make available the funds necessary for the inauguration of a new epoch in this great industry.

While the industry itself has fallen far short of its duty in this matter, some work has been progressing and already seems to justify hopes of the greatest promise. Of course the complexity of the hydrocarbon mixtures in petroleum has proved a serious stumbling block in the way of any thought of utilizing this product as a raw material for synthetics of non-coal-tar origin. The cracking of oil has been widely adopted as a means of keeping up with the constantly increasing demand for motor fuel. In this work it would seem that stress has been put upon avoiding the production of gases as much as possible. Today there are those who are looking at it from an entirely opposite point of view, and while preserving the output in motor fuel, are seeking to increase the yield of gaseous products which

in turn can be separated and converted into products known today but available only in limited quantities. Perhaps it will not be long before more definite information will be available concerning the result of these efforts.

New Type of Research Needed

In the light of the developments and progress at the present time among the derivatives of the hydrocarbons of the methane, ethylene and acetylene series, I would like to make a suggestion for your serious consideration. Through our university courses in organic chemistry we are all more or less familiar with these derivatives, but in a majority of cases we think of them as scientific curiosities or as material available in rather limited quantities and at relatively high prices. The time has now been reached when we are justified in picturing to ourselves practically unlimited quantities of any of these compounds at prices amounting to only a fraction of those of today, if we can find suitable application for the materials. This calls for a re-examination of this great class of substances. For this examination we should develop a new type of research man possessed of a broad training, of a thorough knowledge of the uses of material, of the requirements of various industries and of an imagination which can portray an entirely new order of things. In the training of such men the universities can make a great contribution to industrial advance, and in turn the leaders of industry can in no wise serve themselves better than by the development of that free spirit of intercourse with the university men which was so happily initiated on a small scale at the last Annual Meeting of the Synthetic Organic Chemical Manufacturers Association. Don't misunderstand me. I would not for one moment subtract in the least from the work of our university men in the advancement of pure science, for my conviction is perfectly clear that in the long run those advances are the determining factors in efficient industrial advance. But the universities constitute the training ground for the men who go into research. Already I hear suggestions that perhaps the number of graduate students in chemical research is too large. I doubt this, in view of the great number of industries in this country still failing to make use of research chemists in their further development. But be this as it may, there is a great field open for men possessed of the qualifications to which I have referred, and their efforts should be devoted primarily to this great field of synthetics of non-coal-tar origin. It is more than a question of chemical economics that I have in mind.

And may I at this point say a word to the men of the industry who at times are disposed to speak somewhat contemptuously about the worker in the field of pure science. I know of some who occasionally boast that they never look within the covers of the *Journal of the American*

Chemical Society. But who can tell what product of seemingly little prospect of useful application may suddenly occupy the most prominent place. Lead tetraethyl, already mentioned, is a case in point. And in another field take the matter of the homologs of resorcinol. Doubtless but little attention among industrialists was paid to the work of Professor T. B. Johnson and Frederick W. Lane on these compounds, published in the *Journal of the American Chemical Society* just four years ago. But the extension of this work, to the still higher homologs, by Dr. Veader Leonard, using the methods of Professor Johnson, and a study of their relative bactericidal power showed that the maximum of this power was reached with the normal hexyl derivative, which at the same time proved non-irritating to the urinary tract. Here opened a new chapter in this line of medical advance. Immediately after its public announcement normal hexyl resorcinol occupied the front page in the newspapers of the country.

This brings us naturally to the discussion of that factor which more than any other will determine the future of the synthetic organic chemical industry in America, namely, research, and I use the word research in its broadest sense. Research in the laboratory, in the semi-works plant, in large scale operations, in engineering and especially in chemical engineering, in chemical economics, in the study of markets—in fact in every detail of industrial operation on a scientific basis rather than on tradition and on rule-of-thumb methods.

Problems in Education

For the highest type of this research we must reach back into the high schools and endeavor to attract the best type of these students, and it is highly desirable that such students shall receive the best possible training. For this reason the industry has a very direct interest in the teaching of chemistry in the secondary schools, should lend its aid towards the securing of adequate salaries for teachers and should be interested in every movement that will secure not so much a great quantity of prospective chemists and chemical engineers but the best quality among those who should be encouraged to carry on their training to the highest point.

This factor again makes necessary intelligent interest of our industry in the character of the training given in both the undergraduate and the graduate courses of our colleges and our universities, with every influence exerted to assure the turning out of men with broad educational basis, keen power of reason, skill in technique, accuracy, patience in work and a determination to push through to completion the solution of the problem in hand. It is in the quality of such minds rather than to advanced specialized training that we must look for the man who will carry forward the industry in competition with that of any other in the world.

Finally, the leaders of the industry who have accomplished such wonders

under the stress of national shortage of products during the past decade cannot afford to feel that their task is accomplished now that this shortage has been met. The chemical industry is not a mechanical industry. Research workers cannot be treated as machines. I cannot conceive of any more fertile source of the highest type of researchers than in the American with his inherited pioneering traits, his freedom from the burden of tradition, his adaptability to new situations, and his courage to undertake the solution of any problem.

There is today before us a striking example of an American industry in distress due to failure to recognize these principles. For many years the production of methyl alcohol has proceeded along lines considered thoroughly standardized, making use of available raw material, the forest heritage of this country. Now from the countries of Europe where such a raw material is not so abundant, synthetic organic chemistry seems to have achieved another triumph. While the matter is still hazy because of lack of definite information, nevertheless it does seem that a revolution in this industry is at hand.

Competitive Conditions

Another factor which must influence the future of the industry is the matter of mass production. This is a principle that is primarily American, but in the synthetic organic chemical industry today there is entirely too wide a distribution of manufacture of products for which only a limited market exists. In looking over the Tariff Commission Census it is remarkable to note that although there are still many products to be brought on the market in order to give the desired variety, nevertheless, there are in some cases eight to ten manufacturers of a product whose total annual domestic consumption is not over 50,000 to 60,000 pounds. Such a condition has naturally led to a period of too intense competition, more intense than the strictest letter or spirit of our laws ever contemplated. As a result many of our products today are being sold without any profit and in many cases at a loss. This is an unhealthy condition in any industry. Fair earnings on investment must be obtained if credit is to be maintained, if research is to be pushed, and business expanded, if proper salaries and wages are to be paid, if further capital as it is needed is to be attracted to the field. Not only is the industry subject to intense domestic competition but also has to be constantly engaged with foreign competition. A peculiar feature presents itself in this line of industry. Our chief competitor is Germany. In that country combinations of manufacturers are encouraged, indeed fostered by the national government. And so today, if advance information is correct, there is proceeding a still closer knitting of the dye cartel into one thoroughly unified corporation and this for the avowed purpose of reducing costs of production, distrib-

uting manufacture properly, of gathering up the sinews for an aggressive fight for the domination of the export markets of the world. In sharp contrast to that system of commercial organization is our own where such combinations are illegal, under the Sherman Anti-Trust law. Frankly I feel that our American system is the best in the long run, for while there are certain evident advantages in this monster combination which is now being formed, it must be administered by men who are human beings, with their frailties, prejudices, and jealousies, and it remains to be seen whether the same rate of advancement can be maintained under the new conditions. With us I am confident that the distribution of the industry among large, medium and small producers is a healthy one. It means sharpening of the wits and a more intensive struggle, a constant prod for the large from the small manufacture, all of which conduces to eventual advance. But there is no question of the fact that for the next few years there is grave danger ahead. I deem it a subject well worthy of consideration by those thoughtful men who are charged with administration of our laws, to consider whether the competition of an industry so closely knit as the German industry today is not "unfair competition" with an industry which is seeking to live up to the spirit of the laws of our land.

It must not be forgotten that as a result of the expansion of this industry in many lands an abnormal situation exists. The United States Tariff Commission in the Census of 1923, page 124, says: "The existing capacity to produce in excess of normal requirements cannot fail to result in an era of severe competition in the world's markets, and will finally eliminate many of the plants now producing dyes." Somewhere contraction must take place. I know of no more important question today than the proper working out of this process of contraction so that the result will be an equitable distribution of the synthetic organic chemical industry in many lands.

Foreign Loans Endanger American Industry

Let us not deceive ourselves and fail to recognize the bitterness of the struggle that will accompany that process of contraction. Entirely new phases of the struggle will present themselves from time to time and we must promptly use every legitimate means at our command to cope with them. The most recent development has been the effort on the part of the German Cartel as represented by some of its constituent members to take advantage of the glamor created by the acceptance of the Dawes' plan and to seek to borrow in this country large amounts of capital, which can be utilized either in buying up American plants or in gaining advantage in foreign markets by the granting of longer credits than our industry can afford to give. This statement is not a generalization but is based on definite and specific information. To meet this threat education of Ameri-

can bankers and American investors is necessary. When they understand how intimately synthetic organic chemistry is bound up with questions of economic independence and of national security I am confident that this danger will be avoided. Fortunately, there is a slight lull at the present time in these efforts on the part of the German chemical industry to secure large loans. In this period it is the duty of each one of us to aid the campaign of education, as such loans are not necessary for legitimate carrying on of German industry in the bounds contemplated by the Dawes' Commission Report, as shown by recently published statistics. On the basis of reckoned wealth of German chemical industry prewar as 100, its present wealth is rated at 280. This has been accomplished by the prosperous expansion of the industry during the war period, by the manufacture of large stocks and the cancellation of outstanding indebtedness at but very little cost during the period of currency inflation. If you have not already done so, I would urge that you read a most illuminating article by R. Crozier Long on this subject in the March, 1925, issue of the *Fortnightly Review*.

Patents an Important Factor

Another factor which will play an important part in the future of this industry is that of patents. Perhaps no other branch of industry has been so subject to the influence of this factor as the synthetic organic chemical industry. You are each familiar with the prewar stories of how the rights conferred by our patent system were abused through their utilization for the suppression of industrial development. You know how one phase of this problem was solved by the seizure and sale of these patents to the Chemical Foundation. I am sure that each of you is fully aware of the mass of propaganda, misrepresentation, and scurrilous personal abuse which has been employed in trying to demolish the Chemical Foundation and put an end to the great work it has been doing. In spite of the thorough investigation of the Foundation by the Ways and Means Committee of the House of Representatives in the spring of 1919, similar investigation made by the Senate Finance Committee in the Fall of that year, and a third investigation made by a subcommittee of the Judiciary Committee of the Senate, favorable findings did not clear the atmosphere and it was necessary from every standpoint that a Federal Court should pass judgment on the matter. This was done and after an extended trial Judge Morris of the District Court of Delaware rendered a decision not only upholding completely the legality of the transfer of these patents, but he went further, commending the officers of the Foundation for their faithfulness in executing the trust commended to them, and finally rebuking the Government officers for bringing so many grave charges into Court with so little evidence to support them. Unfortunately, the Gov-

ernment was led to carry an appeal to the United States Circuit Court of Appeals, necessitating further inroads into the funds of the Foundation in fighting this litigation, funds which were intended for use in education and research. Following the presentation of exhaustive briefs by both parties and lengthy oral presentation of the issues at stake this high Court has now by unanimous decision upheld that of the lower Court. What the decision of the Government may be as to further appeal is not yet known. In the light of the decision of the two Courts which have already given such careful review of the entire matter, we can await the final outcome with equanimity. Meanwhile I am sure that we all join in heartiest congratulations to the fighting President of the Foundation, Hon. Francis P. Garvan, and in expressing to him appreciation of his unselfish, patriotic, never-ceasing labors for the cause of chemistry in America.

One of the greatest contributions Mr. Garvan has given to this cause has been the wakening of the nation to a realization of how closely chemistry comes home to every man, woman and child in our country. This has been accomplished through an educational campaign, unique in its character, carefully planned, persistently carried out, though not yet finished. This popular interest and understanding has reflected itself in a most sympathetic and favorable attitude in Congress and the laws now on our statute books are plainly intended for the safeguarding of this industry. While consistent effort is necessary to secure the proper interpretations of these laws that effort is being made and with constant success.

Surely in the light of the surpassing accomplishments of the past ten years in the nation, aroused as never before, with a trained personnel fully able to cope with the most difficult problems, how can one be other than an optimist in discussing the future of the synthetic organic chemical industry in America?

Olive Oil Made Cure for Rickets by Ultra-Violet Rays. That such fats as olive oil and lard may be activated by exposure to ultra-violet rays and used as a substitute for cod-liver oil in the treatment of rickets is shown by experiments about to be reported by the Department of Agricultural Chemistry of the University of Wisconsin in a forthcoming issue of the *Journal of Biological Chemistry*.

Until recent years, rickets has been a scourge among babies. Only within the past few years has science demonstrated that rickets is due to a deficiency of calcium in the bones and that the oil from the liver of the codfish will prevent and even cure the disease.

In the series of experiments now published olive oil and lard were each exposed to the action of the ultra-violet rays from a powerful mercury vapor quartz lamp for periods of time ranging from 30 minutes to seventeen hours.

After exposure to the rays these fats were fed to a group of experimental rats in which rickets had been produced and the activated olive oil and lard were found to have the same beneficial results that followed the administration of cod-liver oil. Not only did the weight of the rats increase, but an analysis of the bones showed an increase in the calcium content.

Some of the activated olive oil that had been stored in a stoppered bottle showed no change in potency after a period of ten months.

It was found also that the fats might be activated by the rays from the open carbon arc, the iron arc, and by sunlight, but that exposure for prolonged periods such as seventeen hours destroyed the potency of the fats, this effect being produced even on the cod-liver oil.—*Science Service*.

OBSERVATIONS ON TEACHING THE HISTORY OF CHEMISTRY

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The Author's Early Explorations
An Experiment in Teaching Chemical History
The Personal Element Essential to Interest
Collections Aid in History Teaching
A Lecture on Lavoisier and His Colleagues
The Misunderstood Priestley
Environment a Factor in History
Outlining the History Course
Overshadowed Chemists
Opportunities for Exploration
American Chemical History
Early Chemical Industries in America
Pioneer American Chemists
George Washington as an Experimenter
Chloroform an American Discovery
Historic Experiments
Collecting American Data
Sources of Foreign Historical Data
American Historians
Treasures in Old Book Shops
Collecting as a Hobby
Personal Anecdotes Valuable
Philosophy of the History of Chemistry

EDGAR F. SMITH

The Author's Early Explorations

Reading this text some may venture the query why anyone should feel called to write upon it. Many questions, however, having been asked regarding it, a personal experience, it was thought, might be given without disturbing or encroaching too far upon academic dignity. The story then is as follows:

As an assistant in chemistry in the University of Pennsylvania, teaching the chemical subjects assigned him, the history of chemistry had never been mentioned to the writer of these lines. He held the coveted doctorate, but never in his pursuit of that prize had he bothered about the history of chemistry. He never heard associates refer to their examiners as having propounded any questions on this particular chapter of the science, consequently few attempts were made to orient himself in it. Further, he had escaped *his* examiners without a word about the subject. But now, as an embryo professor there came the desire to know something of this particular division of the science. Accordingly, night after night was spent with Hermann Kopp's monumental "History of Chemistry." It was read in the original for no one had ventured a translation of the several volumes. There were, of course, struggles with Kopp's cumbersome, involved, and all too frequently occurring sesquipedalian sentences; which evoked, in careless moments, anathemas but, as the days, weeks, months, and years rolled along genuine fondness for this literature was developed. This study inspired and suggested many lines of investigation. More literature on the subject was sought and found in Gerding's

"History of Chemistry," which was fairly devoured, while wonder grew as to why this book had lain so long on the shelf without questioning of its contents. Somewhere it had been observed that Gerding's book had been hastily and carelessly thrown together; but eager to know its contents, this defect, if it ever existed, was missed.

And next—with fearful misgivings—the three volumes of Gmelin's great, stout "History of Chemistry" were taken from their place. This book had been purchased for a trifle and carefully tucked away, really out of sight; but, in this new hour of intellectual awakening, when air castles of every sort were building about the "history of chemistry," the pages of Gmelin were boldly attacked. How dry those pages were. Before their precious nuggets were discovered, the three volumes, comprising the book written in 1798, were turned absolutely aside. They were forgotten and never looked at again—oh! for so many years, for it was never suspected or dreamed that in the closing decades of the eighteenth century two young Americans—Benjamin Smith Barton, author of America's first book on Botany and Adam Seybert, one of America's fathers of chemistry—heard Gmelin's lectures on chemistry, and—who knows?—may have heard the contents of the three volumes on the history of chemistry. At least these young Americans were in Goettingen when Gmelin was writing his books. A nearby picture of the dear old scholar, smiling though he seems to be, has never vouchsafed the slightest scintilla of an answer to the frequent and insistent question as to whether Barton and Seybert listened to his historical talks. Reticent and tantalizing—nothing more.

An Experiment in Teaching Chemical History

But to proceed. Full—too full almost—of information borrowed from Kopp and Gerding, there came the wish to communicate to students something about the early days of the science then engaging their attention. Observe, Thomson's delightful history of chemistry (1831) in two volumes, written in English, and Höfer's two volumes (1869) in French, have not been alluded to, simply because their existence at the moment was not suspected. The source material therefore was Kopp and Gerding. From them voluminous translations were dressed up into readable shape, and under the title, "History of Chemistry," were offered to a class of Seniors, and subsequently to a very small group of men working for the doctorate. And what was the reaction of these students? They received the lectures with respect and some interest; but little enthusiasm was enkindled, because the lectures contained nothing to arouse a spirit of inquiry or to create a very thoughtful attitude. Yet, from an imagined sense of duty these collections of ancient lore were assiduously read for years at their appointed period in the instructional roster. Dissatisfied and heartily disgusted

at the failure to inspire and interest the class, it was resolved to prepare new lectures, as the old ones evidently had been too exhaustive—dry as dust—devoid of the personal, human element—in short, a good deal of hodge-podge. But, they could not have been much else, since their sources had been restricted. They were notes—nothing more—devoid of spirit and life. Again, other volumes on the main subject, besides those of Kopp, Gerding and Gmelin, had been discovered, and in some of them were set forth more intimate pictures of the great actors in the pageant of chemical progress. In the biographical sketches published in the *Journal of the Chemical Society* (London) and in the *Berichte* (Berlin) there was an abundance of material from which could be culled facts about men and their contributions, and so arranged as to interest and teach very effectively.

The Personal Element Essential to Interest

The importance of the personal element was overpowering and could not be dismissed. To illustrate more minutely, it was believed that in presenting Frederick Wöhler, for example, everything concerning the boy life, the student life, and the professional life of that eminent investigator should be woven in with his experimental contributions which had extended the borders of human knowledge. Difficulties, of course, were encountered in developing this vitalizing spirit. It demanded wide, discursive reading; but eventually there was drawn such a picture of Wöhler and his work that its reaction was quickly noticeable in the attitude of the students hearing the story. They behaved as if reviewing the achievements of one who was for the moment in their presence.

As the early lectures were fairly exhaustive it was decided to make selections and write these up after the pattern set with Wöhler. They were to be outstanding figures from chosen periods, not merely representatives of one country, *e. g.*, Germany, but the leading men in the same periods from other countries. Unconsciously, in the earlier lectures, much prominence had been given to German chemists, but subsequent, wider reading disclosed very earnest and creditable masters of the science in other lands; many of whom were studied after the plan adopted with Wöhler. When it came to the selection of the outstanding figures, a map of Europe was placed on the table, and the question was propounded as to what Scandinavians had occupied themselves with chemistry, let us say, in the first half of seventeen hundred (1700), next, what Frenchmen were busy in the same period, then Dutchmen, Germans, Italians, Russians, etc. From this selected group the supposed leaders were brought to the attention of the classes pursuing the history. Afterward, from 1750 to 1800, similar choices were made, and the life stories of the individuals, as far as they were obtainable, were woven into their achievements. The same scheme was pursued for the period from 1800 to 1850. The chemists of the British

Isles were classed with those of Continental Europe. The result was an array of men not so numerous, yet probably similar to many appearing in the textbooks which had grown greatly in number in the days and weeks which passed during the assimilation of material for the revised course of lectures.

In the first set of lectures a rather full account of the infancy of chemistry was favored, and much consideration was given to the achievements of the alchemists; but in the revision the material was drawn quite copiously from "Geschichte der Alchemie," by Karl C. Schmieder, Halle, **1832,** from Rodwell's "Birth of Chemistry," **1874,** and from Siebert's "Geschichte der Chemie," **1886,** as these authors gave in succinct form the essentials of the activities in the science prior to 1700, although Wagner and Siebert also included their views on the men of note of the succeeding eighteenth and nineteenth centuries. At last a new set of lectures was evolved, revised and condensed, without a soporific influence—at least not observable. Furthermore, they really created enthusiasm and eagerness, followed by a purpose to know more of the past of our science. The infusion of the personal element had actually been accomplished in a fair degree. One step, therefore, in what seemed the right direction had been taken, and the lectures were read regularly to classes. Their messages, however, were not all that the students received. There was constant digression and interpolation, so that at the rate of one hour per week, through the year, the time was insufficient for the presentation of the course.

Collections Aid in History Teaching

It had been learned that if, for example, in discussing Scheele, a portrait-print of the savant, an autograph letter and an original publication could be exhibited, the personal element, so greatly desired, was obtained. This led to the search for portrait prints and autograph letters, and accordingly there began a period of catalog reading in these two fields, to which was added later the study of the catalogs of old booksellers, in quest of ancient volumes devoted to chemistry. It was not surprising, then, that there grew (1) a collection of prints, (2) a collection of autograph letters, and (3) a collection of old chemistries. Each of these collections possessed a peculiar fascination and it was earnestly striven to incorporate their attractive features in the revised lectures.

Probably, if in a doubting or critical mood, one may be constrained to declare all this to be a mere collecting mania. This was most emphatically not correct. These assembled collections—portrait prints, autographs, autograph letters and old chemistries—were aids. They were supplementary. All appreciate a chemical museum and admit its value. Its contents frequently have been a blessing in clarifying lectures devoted to

processes as well as to stages in the same, and also in giving students true impressions of much discussed chemical bodies, etc.

On one occasion, with a small group of Seniors, the account of Geber was amplified by reading, in class, chapters from Geber's "Chymische Schriffte," **1710**—abstracted from an ancient manuscript—a facsimile of an example in the Library of the Vatican. The chapters were short. The German was simple and the reading was easy. The woodcut representations of primitive apparatus were quaint and attractive. Something definite was obtained from each chapter. Whether Geber ever really existed in the flesh and wrought the processes described and accredited to him mattered not. Sufficient for the class was that the Geber of the text was understood and fixed in mind never, as years passed, to be wholly forgotten. This, too, was true of his discoveries. Further, the intense interest, the discussions, the marked appreciation and understanding—so evident in the students—were a wonderful satisfaction to the teacher. An old woodcut served as the portrait print. It was not very impressive—its antiquity alone being of interest—and there was no autograph letter or scrap of paper on which Geber's hand had reposed. Yet, for the good fortune of seeing the old book and the privilege of reading a portion of its contents there was gratitude.

The things done by Lavoisier may be briefly and correctly told, and more than ordinary interest aroused by perusal of *Lavoisier* in the fascinating story by T. E. Thorpe in his delightful "Essays in Historical Chemistry," **1902,** or perhaps in Grimaux's *Lavoisier*, Paris, **1888**—a masterpiece of biographical writing—but a gripping interest in the distinguished French chemist and his conquests and devotion to his favorite science will follow, if, in addition to portrait prints (there are many), a letter penned by him be read and pondered upon, and finally if a translation of his volume on the science be read. This textbook announced a new epoch in chemistry. Its author must have been almost consumed with a burning and new zeal, for as one peruses its pages it is instantly recognized that Lavoisier had cast loose from old, age-long moorings and entered enthusiastically upon a new era. Reading page after page of the American edition of Lavoisier's "Chemistry" (the one printed in 1799, in Philadelphia—very rare), the question would obtrude itself as to whether it would not be a good thing to have advanced students, at least, spend a short while in acquainting themselves with the book.

A Lecture on Lavoisier and His Colleagues

Seemingly the efforts of Lavoisier in behalf of chemistry extended far. To corroborate this statement one need only read leisurely the "Method of Chymical Nomenclature prepared by Messrs. de Morveau, Berthollet, de Fourcroy and Lavoisier," translated by James St. John, M.D., London,

1788. This contribution was a most meritorious chapter in the upward progress of our science—a chapter written in France—in her imperial Paris—in the year 1787, thirteen years after the discovery of oxygen.

After reading this book the following word-picture was drawn in the endeavor to impress, more vividly on the minds of students, occurrences relating to the history of chemistry:

It was an epoch-making chapter, the product of four minds—of four actors, if so they may be termed.....in one of the most interesting periods in the history of the French people.

And these four actors were Guyton de Morveau, Berthollet, de Fourcroy and Lavoisier. From time to time they had gathered in consultation in Lavoisier's laboratory. Fancy pictures them seated about a simple board, surrounded on every side with huge volumes and manuscripts, and, suspended here and there on the walls or scattered on the floor, were great retorts, measuring jars, primitive balances, with a huge mercury trough and various other appurtenances for the investigations which had been continuously conducted there in the establishment of fundamental principles of our science. Guyton de Morveau's countenance still retained its lawyer-like expression, though for some years chemistry had been his mistress, and there was visible no sign of the influences of those pernicious political activities which later dominated his thoughts and deeds. Nearby sat Berthollet, whose smiling eyes and winsome manner bespoke a gentle, noble nature, delighting in good deeds to his fellows, with every evidence of an intelligence which might well give birth to a *Static Chemistry* or disport itself in the organization of great schools like the Normal and Polytechnique—with a keen scientific interest in the problem under discussion. And then came Fourcroy—strange being—most agreeable at times, then sarcastic and cunning—able to inspire enthusiasm in his pupils, but yet cold, vindictive, vainly egotistical—a man of moods, though mostly captiously critical. In these particular consultations, however, his bold, saturnine face glowed with animation, while his words flowed rich in constructive thought and happy suggestion. Not yet had the latent fires of hate and destruction made their appearance.

And, in friendliest interchange of ideas shone the *spiritual* face of him who had explained oxidation, combustion, and respiration, as well as the profound principle of the indestructibility of matter. That was Lavoisier, the dominant figure in the group of actors; all antiphlogistians. Convinced of the correctness of the function of oxygen in chemical reactions, cognizant of the simplicity it ushered into the prevailing chemical thought and wearied by the burdensome nomenclature which had accumulated through the ages, they regarded it a duty, incumbent upon them, to let their light illuminate the darksome expressions which enthralled all chemical literature. And, thus, out of their numerous conferences came the light which promptly shone everywhere. Its welcome rays made our tasks as chemical students lighter and endurable. And to that little group of actors, chemists of all time will be indebted. For that reason I am here, lest you may forget the debt you and I owe Guyton de Morveau, Berthollet, Fourcroy and Lavoisier. They had chafed under the chaotic condition of chemical literature, but discerning a new path they made bold to pursue it, and were

> ranked among the first chymists in Europe—

but not until they maturely studied the

> metaphysic of language, and the conformity of ideas with words, did they venture to present their gene:al nomenclature.

True, under Bergmann, Buquet, Macquer and Fourcroy

> the nomenclature of chymistry had acquired considerable improvement,

but only after many sessions and protracted deliberations did de Morveau, Berthollet, Fourcroy and Lavoisier come into the open with their new ideas, supported and greatly encouraged by the message of Bergmann, written shortly before his death:

> Have no mercy on any improper denomination. Those who have known chymistry will always understand; those who do not as yet know it will understand the sooner.

That was the message!

And now, together, let us inspect the nomenclature of chemistry as it was in the period to which the preceding observations refer. Suppose I should speak the words *potassium sulfate*—just those two words. At once each of you recognizes a familiar body. It is an old friend. Its properties loom up before you. But, if I had said hand me a bit of *sal polychrestum Glaseri*, or *Tartarus vitriolatus*, or *Vitriolum potassae*, or *Sal de duobus*, or *Arcanum duplicatum*, where would you be? And yet these names represented potassium sulfate. They were in number five—a burden to the memory, and in no instance giving the slightest indication as to what was meant. At least we would say so. They were also a burden to those four devoted *first chymists*, for Lavoisier wrote:

> many of the chymical terms have been introduced by the alchemists: terms which we should not expect to find perfect, knowing how difficult it would be for the authors to convey to the readers a knowledge which they had not themselves; I mean ideas agreeable to truth and accuracy. Moreover their design was not always to speak so as to be understood. They made use of an enigmatical language peculiar to themselves, which in general presented one meaning for the adepts and another meaning for the vulgar, which at the same time contained nothing that was rationally intelligible either for the one or the other.

On proceeding further it will be discovered that a *Death's head* signified a vessel for distilling, and that *Caput mortuum* was the residue left upon distillation.

Powder of algaroth, salt of alembroth, pompholix, phagedenic water, turbith mineral, aethiops and others are neither less discordant, nor surely less extraordinary; continual practice and great memory are necessary to retain ideas of the substances indicated by such terms, and especially to recollect to what genus of combination they belong.

The terms *oil of tartar by bell, butter of antimony, butter of arsenic, flowers of zinc*, etc., are still more ridiculous, because they give birth to false ideas; because properly speaking, there does not exist in the mineral kingdom, either butter, or oil, or flowers; in fine because the substances expressed by these deceitful names are for the most part violent poisons.

Ponder for a moment on simpler terms; for example, *argillaceous salt of fat*, or *subaceous salt of gold*, or *magnesia salt of Prussian blue*. These mean nothing to us. They would indeed weary us. While probably we would denounce in strong terms *Spiritus sylvestre of Helmont* when we learned it was only carbonic acid, or *nitre of ponderous earth* when we heard it really was barium nitrate, or *gas phosphoric de M. Gengembre* when subsequently it became known that it was merely *phosphine*. But, can you imagine our consternation and nervous condition did we have to confront such a nomenclature today! And the *Lily of Paracelsus?* A lily suggests something beautiful, and attractive, but the *Lily of Paracelsus* was only caustic potash from alcohol!

And when we consider that our four actors were engulfed in the voluminous, ponderous chemical literature of the ages that had intervened since our science was cradled in darkest Egypt, we begin to fathom the Herculean task on which they embarked, in order that light and scientific accuracy might prevail in the literature of our science. To our minds they are heroes. Our admiration for them becomes boundless. We worship their memories, for it is the only way in which our gratitude can express itself.

Eventually, our four actors completed their labors. Recognizing that these were

in a sense revolutionary, yet quite sure that if the results were properly promulgated before intelligent audiences the outcome would be a universal and emphatic approval, they modestly addressed that august assembly—the French Academy—informing those distinguished savants that, with the recognition of the function of oxygen in the chemical world, they were able to classify and arrange matter into a few simple groups; and, further, that there logically followed a simplification in chemical nomenclature.

And then on April 18, 1787, Lavoisier, as first speaker, addressing the Academy, said:

> Not until we had reviewed every part of chymistry, and maturely studied the metaphysic of languages, and the conformity of ideas with words, do we venture to present this general nomenclature.

In a brief sketch, beautiful in its simplicity and diction, the great leader proceeded:

> to remove the impediments retarding the progress of chymistry.

Involuntarily, the thought comes, how grand it would have been to have been present on that sublime occasion!

Having thus elucidated the causes for their labors and the concomitant results, on May 2, 1787, de Morveau addressed the Academy, taking as his task the explanation of

> the principles of the methodical nomenclature;

then commented on the substances approaching nearest to a state of simplicity; on the radical principles of the acids; on metallic substances; on the earths; on the alkalies; and general reactions of compound bodies. It was a remarkable disquisition as every student will declare upon reading it.

And next followed de Fourcroy, displaying tables of arrangement of the nomenclature. This was no easy problem, for with the tables explicit and detailed explanations were given, to which he added on closing:

> If greater facility in study and more perspicuity in expression result from these innovations as the trials which have been made this year (1787), in the public lectures at the Jardin du Roi and at the Lyceum, give us reason to expect, the reformation which we propose, founded upon the most simple method, must certainly be favorable to the future advancement of the science (chymistry).

This, too, was a remarkable address, delivered before an impartial and impassive judge that

> applauds the efforts made under its inspection to do away errors and prejudices and to extend the dominion of truth; but—slow to pronounce.

Nevertheless, the august body joined in the universal acclaim accorded this brilliant effort and exposition.

Berthollet's portion, in the final presentation, appears to have been that of a general elucidator; one intent upon the whole procedure, here and there emphasizing and coordinating the various minor corrections, and refreshing the memories of the auditors upon sections of the work which had been momentarily forgotten.

It was, indeed, an epoch-making chapter which our "four actors" wrote, but rarely do we stop in our onward progress to give it consideration. Our enjoyments, our privileges as a rule hark back to grand, heroic efforts, and not seldom to deepest sacrifices.

In my possession is a remarkable picture bearing the title *The Arrest of Lavoisier.* Yes, only a few years subsequent to those red-letter days in the French Academy, our four actors appeared under other conditions. The awful Revolution and Reign of Terror were approaching. De Morveau apparently had lost every recollection of his mistress, Chemistry! As a member of the Assembly and Convention, he led in the wildest revolutionary outbursts and movements. Berthollet sought kindlier surroundings

because averse to these fratricidal premonitions, but Fourcroy was most active. Everywhere his spirit controlled and directed. With him there was but one desire and that the destruction of government and those who in any way befriended it. Hence, Lavoisier soon became to him an object of hate, for the latter labored only for his country's good—not, however, as Fourcroy saw the good; so it was the maddened fury of Fourcroy that occasioned the arrest of Lavoisier, for he was relentless—his object was to crush Lavoisier.

And, there, in the picture stands Lavoisier, majestic in attitude and mien, confronted by a mob which had with violence gained access to his laboratory. The scum of Paris, armed with bayonets, clubs, with the crudest instruments of destruction, howled, sneered, and derided the noble soul, until a pompous leader with a victory cap on his head and a brilliant girdle about his loins, haughtily delivered the contents of the paper of arrest to Lavoisier. It is a picture that rivets attention, depicting as it does, a stirring scene—yet horrible as its consequences are recalled. After the arrest, came the trial and condemnation.

When again you visit Versailles fail not to study the canvas entitled "The Last Call." Once more, it is the immortal Lavoisier, calm and serene, rising in response to the raucous command of the gendarme—and resolutely proceeding with brother prisoners to the rear of the historic Madeleine, into the cemetery of which were to be thrown, after the guillotine had done its work, all that was mortal of this fourth member of our little group of actors, and the place of his interment forgotten.

Silently reviewing these closing scenes one involuntarily exclaims—what a jury and what a trial! Facts misrepresented and the defence given no chance to prove this. False testimony accepted, and the defence prevented from showing it up. Everything done was, however, in strict accordance with the letter of the law; so was the trial of Galileo before the Inquisition, so was the trial of Socrates at Athens, and so was the trial of Christ before Pilate. In the name and according to the letter of the law, the greatest crimes, condemned by history, have been committed. When the heart of man has become corrupt, even the law is made an instrument of crime.

After delivering the preceding sketch, portrait prints and autograph letters of "the four actors" were exhibited.

The Misunderstood Priestley

On examining the record—the life record—of Joseph Priestley much material presents itself, but in spite of this the student is prone to think of him only in connection with the discovery of oxygen, and pretty sure also to inject the statement that priority in this discovery belongs to Scheele, or at least they were co-discoverers, entitled to equal credit. There is nothing wrong in this, but usually there is added that Priestley was a "fakir," a dissenter, a cantankerous, difficult individual! The unfortunate feature of such talk lies in the fact that all the while the other splendid scientific work of Priestley is forgotten, especially those real classics "on the Air." Reading them brings again to the fore the true scientific investigator and the wealth of his discoveries. They are admired. Priestley, the dissenter—the radical—gives way to the man of scientific instinct. The books on "Air" were translated into German, French and other languages because of their genuine merit.

Environment a Factor in History

In studying the history of chemistry, while giving consideration to meritorious individuals and their particular contributions to the extension of the borders of human knowledge, attention should be given to their environment. What was the governmental state of England when Priestley lived? Who were his associates? What was England's industrial condition? If it pleases, one may properly ask what sociological conditions prevailed in England in the days of Priestley—and not only there but in France, in Scandinavian countries, in Germany and elsewhere? If one were favored with records of the transactions of the ancient "Lunar Society" very probably great light would be thrown upon a group of eminent scientists, their aims, ambitions and discoveries, and among these would be Priestley. It must not be overlooked that it was the urging of the immortal Franklin which led Priestley to study political science; that teacher and taught held very similar views in this field. Again, one regrets that this ardent zealot in so many directions felt called to enter the polemical field in government and religion, because vastly more could have been accomplished in experimental science, yet when one reads "Tracts," by Samuel, Lord Bishop of St. Asaph, 1st American edition, **1821,** it is easy to comprehend why the Doctor should have entered with a certain human bitterness into the controversial field, for it was believed that the most effectual preservative against Priestley's mischievous performances "was to destroy the writer's credit, and the authority of his name, which the fame of certain lucky discoveries in the prosecution of certain physical experiments had set high in popular esteem, by proof of his incompetency in every branch of literature, etc." So Priestley was charged "with reasoning in a circle, with instances of quotations misapplied through ignorance of his subjects; instances of testimonies perverted by artful and forced constructions; instances of passages in the Greek fathers misinterpreted through ignorance of the Greek language, etc." His opponents imposed burdens and to clear them away he devoted much time with the sole result of multiplying his task, and neglecting his favorite science. Yet in telling the story of Priestley's life, a knowledge of these digressions, on his part, are needful to fully comprehend him. It must be confessed they tend to submerge his scientific work, and many remark casually and carelessly that Priestley happened to discover the greatest of our elements, and that he was nothing more than a turbulent busy-body, losing sight of his beautiful "Natural Philosophy," London, **1779,** and the sequel "Observations on Air," London, **1781.** The historian of chemistry, familiar with Priestley's excursions into the field of politics, into the field of religious dogma—into literature, of which his "Grammar," London, **1768,** is a worthy example—into art, as seen in his book on "Perspective," London, **1780,** will give a just and com-

plete picture of him, and also the sanest evaluation of his scientific activities.

Outlining the History Course

Such digressions as have been here indulged in suggest many illuminating pictures, which for the moment, must be placed in the background, in order that an outline may be given of the eras into which the evolution of chemical science may be divided. They are:

1. The Chemistry of the Ancients (up to 300 after Christ).
2. Era of Alchemy (from 300 to 1525).
3. Era of Chemiatrics or Medical Chemistry (from 1525 to 1650).
4. Era of Phlogistic Chemistry (from 1650 to 1775).
5. Era of Analytical Chemistry (from 1775 down to modern and very recent times).

This is an arbitrary division. The teacher need not adopt it. It is suggestive and nothing more. Each era may be developed according to the lecturer's idea of the importance of the individuals actively at work at the time. But, upon casting about for the filling-in material, very interesting data will be gathered. And where may this material be discovered? In the earliest publications of a period—in manuscripts, in early books, in the earliest journals devoted to chemical studies. They are the genuine source material; for example—

(1) *Allgemeines Jour. der Chemie, von Alex. Nic. Scherer, Leipzig. 1798–1803.*

Continued under the name

Neues allgemeines Journal der Chemie, von Klaproth, Hermbstaedt, Scherer, J. B. Richter, J. B. Trommsdorff, etc.

and further continued under different names until it reached that of

Journal für prakt. Chemie, 1826, etc.

(2) *Annales de Chimie, etc., par de Morveau, Lavoisier, Monge, Berthollet, de Fourcroy, de Dietrich, Hassenfratz et Adet-Paris, 1789–1816, and its sequels.*

(3) *Annali de Chimia, di L. Brugnatelli, Pavia, 1790–1802.*

(4) *Annals of Philosophy by Thomas Thomson, London. 1813–1820.*

(5) *Die neuesten Entdeckungen in der Chemie, gesammelt von Lorenz Crell. Leipzig. 1781–1786.*

and numerous other publications, which are accessible in the larger libraries, and gladly offered to investigators at a distance. If working in German literature the *Letters* of Wöhler and Berzelius, those of Wöhler and Liebig, those of Berzelius and Liebig, as well as the delightful monographs of Kahlbaum and others must not be overlooked.

Overshadowed Chemists

Again, the earliest chemical textbooks contain information which the student of the history of chemistry should know. Many surprises are

found. New characters are introduced. They have not been mentioned in the customary texts of the history of chemistry, or if mention was made it was in such meagre form that no impression was left on the mind of the reader excepting, possibly, that these persons were unimportant. Yet as one pursues them in their contributions to chemistry, the thought comes that they should have a place—a prominent place—among the leaders. These men constitute a group to which Dr. Lyman C. Newell has applied the term—"overshadowed chemists." Just why this should have been their fate is not easy to comprehend. Take the case of Franz Carl Achard. Who was Achard? In which of the many histories of chemistry may one see his name or mention of his splendid achievements? He was one of Marggraf's pupils and in the course of the years seriously strove to make practical Marggraf's scheme of extracting sugar from beets. And of Marggraf himself too little has been given to the inquiring student. He also is in the group of "overshadowed chemists" but for the best of reasons should be taken out, and properly introduced to modern chemists. He was the regenerator of European chemistry, and one of those very early workers of whom the Englishman, Robert, Kirwan remarked:

> of this truly philosophic band, Mr. Marggraf of Berlin, led the van.

And there was Chaptal, a very unique and inspiring figure. In 1893 his great-grandson published Chaptal's *Autobiography*, giving also, from stray notes, his own story of his eminent ancestor so as to bring the life picture down to 1832.

Today it is deplored that chemists devote themselves so rarely to public problems. On reading Chaptal's *Autobiography* one is fairly astounded on hearing of his achievements, for he did so much for France through his science.

Again, turning to source material one discovers much that is new and helpful relating to known men. On reading Lorenz Crell's biographical sketches of Bergmann and of Scheele, as they appeared in Crell's *Annalen*, newer pictures of these eminent persons are obtained. Crell conversed with them, associated with them, and was their constant correspondent, so that his picture of them is at first hand.

And Ingenhouz certainly deserves fuller presentation than is usually accorded him. He was a travelling scientist, especially partial to chemistry and physics, and an intimate friend of Benjamin Franklin. Probably readers of these lines will recall that on the occasion of Sir Henry Cavendish's introduction he made his bow and in some most mysterious way disappeared from Ingenhouz and his friends. This conduct was attributed to Cavendish's painful shyness, but as one peruses the story of the curious little gentleman—Ingenhouz—one learns that he was intensely interested in platinum, and that he wore a coat mounted in platinum

buttons. The latter may have so amazed Sir Henry Cavendish that he escaped unceremoniously from Ingenhouz! The latter experimented largely on vegetables "demonstrating their power of emitting vital air in sunshine and nitrogen at night." He claimed also to have prepared gunpowder without sulfur, and called attention to the inflammable gas arising from heating a mixture of alcohol and sulfuric acid. He did much to promote science. His books were translated into English, French, and Russian.

Opportunities for Exploration

Advancing thus in the study of the available literature of the science a vast field opens up to the inquirer, and he soon recognizes that the entire story cannot be given in one book, or in one course of lectures, in fact not in years. Yet this overwhelming condition should not be a deterrent. On the contrary, chapters may be offered to classes with excellent results. Because of its comprehensive nature, the history calls for researchers who will occupy themselves with its sensible evolution and unfolding. Why should not doctoral theses be permitted in the division of the history of chemistry? One result of such work would be the recognition of the dignity of chemistry, of the struggles and revolutions down the ages through which it has passed, and then finally a keener, fuller appreciation of the meaning of the science. Thus, if one were to trace the historical development of the doctrine of chemical affinity from its founder, Newton, to Franz Goeffroy, to di Limbourg, to le Sage, to Gellert, to Bergmann, to Berthollet, then to the moderns, there would come to the inquirer a reverence for these profound thinkers and experimentalists. How they longed for the truth! Their mental agonies—for such they were—can almost be sensed by the thinking student, particularly if he has familiarized himself to a degree with the personalities of these ardent searchers after light and truth! One can almost see the profound expression on the countenance of Goeffroy as he first reads that early suggestion of Newton regarding the attraction between the smallest particles of matter, and then hear his question—"are the transpositions I am conducting so controlled?"

Another topic worthy of elucidation would be the evolution of chemical apparatus. A mere glance at *Schreger's Beschreibung der chemischen Geräthschaften älterer und neuerer Zeit als Beitrag zur Geschichte der Erfindungen in der Chemie*, Fürth, 1802, will suggest the line of study. The outcome will more than repay those who venture upon the undertaking. In the end it will be an additional chapter in our wonderful science.

Those partial to industrial chemical pursuits should turn to Diderot's monumental and enormous *Encyclopædie*, the first volume of which appeared in 1751, and the remaining sixteen, as well as eleven volumes of

plates, in the years between 1751 and 1765. After examining this masterpiece one comes back to ordinary duties in a reverential mood, with the avowed determination that students shall know the past. It is not dead.

American Chemical History

Years devoted to the study of the literature of chemistry in all parts of the civilized world, seeking to understand the exponents of the science and tracing its ramifications in the social life of great nations—culminated at last in the query as to whether in our own land there had been "beginnings" in our science. That query will come to every American student of chemistry, sooner or later, if he permits himself to ponder on the earliest records of the science. Yet, probably, most teachers of chemistry will confess, if pressed, that it had not occurred to them that there was an American history of chemistry. Indeed, there have been those who expressed real surprise on hearing that such was actually the case. The truth is that most of us, on mention of historical chemistry, have turned to foreign sources for the facts. We have been fed up on foreign literature.

The preceding paragraphs are the confession of a single individual and they represent his experiences in seeking light in order to tell the story of a science to which his life has been given. The source material proved of such value that there resulted the desire to call the attention of other teachers to it. And so when search was made for the earliest records upon chemistry in this country there came the conviction that America had much to offer in the nature of a history of chemistry within its borders. It seemed that from 1775 to the present there were immense stores of chemical literature, yet what might have occurred prior to that early date had no significance, so that a debt of gratitude is due Dr. C. A. Browne for calling attention to the alchemists who flourished in this country. Would that he had time to send out his John Winthrop, the Younger—one of the most interesting of American alchemists. Dr. Browne found them elsewhere than in New England, and gave a short account of some of them in a recent issue of *Industrial and Chemical Engineering*.

Early Chemical Industries in America

In perusing the history of chemistry in America, it will be well to study an early map of the Atlantic Coast, noting particularly the points favorable for incoming vessels. Afterwards examine the volumes relating to travel in America in the earliest days. This has been but moderately done. The scheme should be searchingly tried out. There is promise of rich findings in regard to the earliest efforts to plant chemical industries in this land. So far as known, Jamestown, Virginia, enjoys the honor of being the spot in which a glass house (1608) and iron reduction furnaces (1619) were operated. Next it was in Massachusetts that efforts along many lines of

industrial chemistry were set in operation. Chemists in and about Boston have precious historical material in the library of the Massachusetts Historical Society waiting for their study.

And it means something to know that as early as 1743 (or perhaps even earlier) the indigo plant was grown in South Carolina. Miss Eliza Lucas was a pioneer. The coloring material extracted from the leaves by her was sent to England as well as used at home. South Carolina taught the people of Georgia the art of growing the plant and extracting the color. In the South and Southwestern sections of our country in Colonial days, chemistry was active in industries.

Pioneer American Chemists

In Philadelphia chemistry as a science took root early in the seventeen-fifties, although its industrial applications received quite early very earnest consideration. The coming of Joseph Priestley in 1794 introduced new life into the younger men devoted to the science. They eagerly responded with splendid work. They were mostly the pupils of Benjamin Rush, "Signer," who in 1769 assumed the first independent chair or professorship in the country, and published "Chymical Syllabus" in **1770.** This was the first chemistry written by an American. From Philadelphia the incentive to research in the science went north and east, then to the south. And it is chiefly the colleges and universities to which one must turn to meet the individuals who were so occupied.

Some years ago there was published by D. Appleton & Co. a book entitled "Chemistry in America." Herein are mentioned the earliest participators in this movement. Time has demonstrated that much more lies behind these "fathers in chemistry in America," and that their achievements are crying for fuller presentation. So believing, the author of the volume just mentioned sent out a Biography of Robert Hare, another of James Woodhouse, another of James Cutbush, and brochures upon Samuel Latham Mitchill and eight or ten other real "worthies." What these men accomplished in our science in this land is most astonishing and should be in the ken of modern students of chemistry. No course of lectures on the history of chemistry delivered in our institutions of learning should be given without a large chapter upon the rise and development of the science in America.

George Washington as an Experimenter

The story of American chemistry is most fascinating, able to arrest even the attention of neophytes. For example, is not the following account of the intense interest of our first President worth relating, when marsh-gas, methane, is discussed with beginners, or even with advanced students? The keen, untiring search of Dr. C. A. Browne brought it to light. The

Doctor correctly designates it "an experiment performed by George Washington upon the Production of Marsh Gas" in the course of which he says that Thomas Paine wrote:

In the fall of the year that New York was evacuated (1783), General Washington had his headquarters at Mrs. Berrian's, at Rocky Hill, in Jersey, and I was there. The Congress then sat at Princeton. We had several times been told that the river or creek that runs near the bottom of Rocky Hill, and over which there is a mill, might be set on fire, for that was the term the country people used, and as General Washington had a mind to try the experiment, General Lincoln, who was there, undertook to make preparation for it against the next evening, Nov. 5. This was to be done, so we were told, by disturbing the mud at the bottom of the river, and holding something in a blaze, as paper or straw, a little above the surface of the water.

Cols. Humphries and Cob were at that time aides-de-camp of General Washington, and those two gentlemen and myself got into an argument respecting the cause. Their opinion was that on disturbing the bottom of the river, some bituminous matter arose to the surface, which took fire when the light was put to it. I, on the contrary supposed that a quantity of inflammable air was let loose, which ascended through the water, and took fire above the surface. Each person held to his opinion, and the next evening the experiment was to be made.

A scow had been stationed in the mill-dam, and General Washington, General Lincoln and myself, and I believe Colonel Cob (for Col. Humphries was sick), and 3 or 4 soldiers with poles, were put on board the scow. General Washington placed himself at one end of the scow, and I at the other. Each of us had a roll of cartridge paper, which we lighted and held over the water, about two or three inches from the surface, when the soldiers began disturbing the bottom of the river with the poles.

As General Washington sat at one end of the scow, and I at the other, I could see better anything that might happen from his light, than I could from my own, over which I was nearly perpendicular. When the mud at the bottom was disturbed by the poles, the air bubbles rose fast and I saw the fire take from General Washington's light, and descend from thence to the surface of the water, in a similar manner as when a lighted candle is held so as to touch the smoke of a candle just blown out, the smoke will take fire and the fire will descend and light up the candle. This was demonstrative evidence, that what was called setting the river on fire, was setting the inflammable air on fire that arose out of the mud. I mentioned this experiment to Mr. Rittenhouse, of Philadelphia, the next time I went to that city, and our opinion on the case was that the vapor that ensued from any combustible matter (vegetable or otherwise) that underwent a dissolution and decomposition of its parts, either by fire or water in a confined place, so as not to blaze would be inflammable, and would become flame whenever it came in contact with flame.

This is a bit of a story regarded by some, perhaps, as not entitled to place in any textbook devoted to chemistry, yet the teacher of beginners in organic chemistry, when discussing this simplest of hydrocarbons, could, with propriety tell it. It would be repeated by students, for every act of the greatest of Americans always arrests attention.

Chloroform an American Discovery

And, when discussing chloroform, would it not be in order to quietly add that ninety-five years ago Samuel Guthrie wrote Silliman, the Elder:

Into a clean copper still pour three pounds of chloride of lime and two gallons of well-flavored alcohol of sp. gr. 0.844 and distil. Watch the process, and when the product ceases to come, highly sweet and aromatic, remove and cork it up closely in glass vessels.

Chloroform was thus discovered and made by the bleaching lime procedure! It was the work of an American. He was also the first to publish an account of its therapeutic effects as a diffusible stimulant, and so became a real benefactor to mankind, which all will admit, on pondering for a moment the benign influence of chloroform as an anaesthetic, for

> There is
> No danger in what show of death it makes,
> More than locking up the spirits for a time,
> To be more fresh, reviving.

This is a chapter of home endeavor in the organic division of our science. It was first written in a now "historical laboratory," located in the wilds of the State of New York, away from seats of learning and remote from the arteries of commerce, by a man of medium stature, slender build, dark complexion, slightly stooping figure and thoughtful mien. Even the close observer of the throng in New York, in which he frequently mingled, would not think, on encountering him, that he had jostled a man whose fame as the discoverer of chloroform, and whose work in other original scientific investigations gave him rank among the eminent men of that period.

Historic Experiments

Every teacher of experimental chemistry has, in carrying along a class of beginners, made the demonstration of the compound nature of water by passing steam over heated iron filings, collecting at least the liberated hydrogen, or it may be he has made it more elaborately, but no matter when or how he has done it, he has repeated Lavoisier's classic experiment. It is a time-honored procedure. Chemists of today continue to appreciate its value. They may be extreme modernists in their views but in doing this experiment they lean on the past.

And, again in introductory courses, when discussing analysis and synthesis, there surely is made that synthesis—*viz.*—the heating of finely divided copper or iron with sulfur. Once more, in so doing, one falls back on the past. Two hundred years ago four members of the Association of Dutch chemists performed this experiment. It meant much to them. They were congratulated by their colleagues. It was a red letter occasion when they gave a public demonstration. Today, the experiment belongs to the ages. Questions regarding its origin are not asked. No one is concerned and perhaps that is right, but now and again curiosity prompts the query as to who possibly first made this experiment. Precisely the same

is true of the production of phosphine on heating yellow phosphorus with caustic soda. Phosphine is formed, and the origin of the procedure never enters the thoughts of students. It is not a vital matter. But, still, is there not a vitalizing element injected on mentioning that almost two centuries ago de le Gengembre, in working with phosphorus, came upon this gas? It introduces one who was interested in their science. It presents, too, an "over-shadowed chemist" from France. There are additional points about the four Dutch chemists and about de le Gengembre which might be given to increase the human side of the work. The knowledge that men—men who lived long ago—busied themselves with the substances upon which students now are engaged—helps impress facts. And it may be observed that all this experimental work is shot through and through with the human element. If it is brought out before classes good will result. Chemistry will cease to be regarded as a strange science.

Collecting American Data

But, to return to the history of chemistry in America. It might be presented in several chapters. The first would be devoted to the alchemists; the second to a period extending from 1750 to 1825; a third, to a similar period from 1825 to 1875, including in the latter all that has occurred since that year. The application of chemical principles to industries will loom up strongly as will also mineralogical chemistry, and there will be numerous data on agricultural chemistry and upon organic chemistry.

Graebe has just completed a volume on the history of organic chemistry. Why should there not be volumes on the history of chemical analysis, on applied chemistry, on physiological chemistry, etc., each an unique and distinct chapter, setting forth the activities in each of these departments, in all parts of the civilized world? Combined they would constitute an exhaustive history of chemistry.

If the history of American chemistry is to be offered what steps should be taken to assemble the material? One is forced to study, first the earliest literature of the several colonies. Such study will point the way to facts and to individuals. Early newspapers should be closely scrutinized. The earliest literary magazines contain valuable information for the student of historical chemistry.

The records of Continental Congress have a broadside printed in 1775 on niter, its preparation and its uses in gunpowder manufacture. This was presented by Benjamin Rush to whom brief mention has already been given, and in the *Pennsylvania Gazette* for January 18, 1775, it was announced that Dr. Rush expected to deliver "eight lectures on such parts of chemistry as abound with the greatest variety of the most useful and entertaining facts, etc."

The proceedings of the early learned Societies will also reveal much ma-

terial of value and interest. It must not be forgotten that in 1792 the Chemical Society of Philadelphia was founded. It continued to 1809. Its minutes have not yet been entirely discovered. Fragments have come to light. They are very helpful. The annual addresses before that Society, so far as discovered, have been most illuminating. Then in 1811, the Columbian Chemical Society had its birth. Its single printed volume of *Memoirs* appeared in 1813. It is marked Volume I; whether there were other volumes is not known. They are being sought.

The earliest chemical textbooks give some assistance. But after the publication of Rush's *Syllabus*, **1770,** the next American venture into the field of independent authorship was James Cutbush's "The Philosophy of Experimental Chemistry," **1813.** In the interval between the appearance of these two books, there were, it is true, issued by American publishers many reprints of English books. The latter, generally annotated by their American editors, gave fair pictures of the status of chemistry in this country. The *Medical Repository* founded by Samuel L. Mitchill in 1792 contains much chemical material, as well as communications on geology and mineralogy. The *Medical Museum* has buried in its pages, covered over with pure medical facts, some very interesting pioneer chemical data. Throughout the young Republic isolated publications of longer or shorter life carried quite a bit of chemistry. True, there is thus necessitated quite a range of reading for the teacher, but it will be profitable. The thought of this character of work may at first blush act as a deterrent; this, however, is but a temporary or passing idea, and soon the desultory task proves most attractive and the discoveries sought generally grow in number. The great publication centers in those early days were Philadelphia, New York, Boston, Baltimore, Charleston, S. C., and smaller cities such as Burlington, N. J., Lexington, Kentucky, and others, and to them it will be wise to turn in leisure moments.

Sources of Foreign Historical Data

In preparing lectures on the history of chemistry (other than that of America) one turns to Germany, where this class of literature has always been abundant. No other country has done so much. In France there have been comparatively few separate volumes on historical chemistry. The French have contented themselves with rather elaborate eulogies of men eminent in chemistry, and if publication followed it was in transactions of learned societies—usually not accessible to the great family of students.

In England, Thomas Thomson's "History of Chemistry" was the pioneer. Since his day quite a number of volumes on the subject have appeared. The desire for such literature is growing in that country. In Scandinavian lands, in Italy, in Russia and in Holland there has been much to reward the student's search.

American Historians

In our own country in 1812, Thomas Cooper published an *Introductory Lecture.* On the tenth page of the lecture appear the following lines:

> I well know that modern authors on Chemistry and even the compilers of the most acceptable elementary works, decline entering upon the history of the science they profess to teach, as comprehending only a dry investigation of facts, and dates and names, uninteresting to the student, because almost unintelligible at the outset of his studies; and communicating no practical Knowledge. Hence I am unacquainted with a tolerable History of Chemistry in the English language.

Cooper was an Oxford man widely conversant with the sciences, with medicine, with law, with literature and with history, hence his closing sentence in the preceding paragraph would point to little activity along chemical historical lines in his native land. But, he continues:

> It appears to me that the history of an art or science is a proper introduction to the study of it; especially of Chemistry, as containing areas of discovery intimately connected with controversies yet unsettled, and therefore worthy to be known—as giving a clear and concise view of the manner in which improvements have been effected—as exemplifying the general utility of Chemistry—as furnishing due caution against future errors, by exhibiting the mistakes of superior minds of older times—as rendering merited honour to those who have benefitted mankind by their discoveries—and as comprising in a connected detail, those periods and gradations of improvement, which would not so distinctly dwell upon memory, if delivered in an insulated manner during the occasional illustration of some particular experiment.....I propose therefore to enquire what was known of the Chemical Art, in the earliest stages of Society, etc., etc.

He then proceeds to unroll a most interesting history of chemistry. Would it be claiming too much to say that Cooper's essay represented the first history of our science written and printed in America?

As confirmatory of his reasons for writing the book there may be added the following view of Khanikoff who wrote:

> The history of the sciences presents to us an incontestable fact of deep significance; the rediscovery in modern times of truths laboriously established of old; and this fact is of itself enough to indicate the necessity of searching carefully in the scientific heritage of the past after all that it may be able to furnish us for the increase of our actual knowledge; for a double discovery, necessarily requiring a double effort of human intellect, is an evident waste of that creative force which causes the advance of humanity in the glorious path of civilization.

If it is granted that Thomas Cooper wrote the first American history of chemistry, there must next be aligned with him Professor Venable and Professor Moore. Their productions are of more recent date and familiar to most readers of chemistry. Their respective volumes are excellent and about them may be built elaborate and comprehensive courses on the history of our science. To these authors, justly entitled to highest praise, must be added the late Professor John M. Stillman with his "Story of

Early Chemistry." And with the quartette: Cooper, Venable, Moore, and Stillman, should be mentioned H. Carrington Bolton, formerly of the chemical staff of Columbia University, subsequently Professor in Trinity College, Connecticut—a scholarly gentleman whose interest in the history of chemistry was absorbing and productive of many valuable and excellent contributions, scattered about in numerous journals. In the *American Chemist* beginning in 1870 as the successor to the *American Reprint of the Chemical News* will be found numerous charming historical papers by Bolton. He long prosecuted his researches in historical chemistry quite alone, giving much time in European lands to study in this field and gathering priceless volumes on the science. His volume on *The Scientific Letters of Joseph Priestley* is evidence of the thorough manner in which he carried forward his historical studies. It is a delightful volume. But, a greater debt is due Bolton for his monumental work—*A Select Bibliography of Chemistry 1492–1892*, and its supplements. With these the student of the history of chemistry may be guided in the collection of source material for his studies. Hours pass too rapidly when engaged in the study of the contents of this book. Every chemist who cares for the history of his science should use Bolton's work. He soon will declare, if he follows the silent suggestions of the book, that the policy of each generation should be not to break with the past—which can never be done—but to utilize the experience of the past for the benefit of the present and of the future.

Treasures in Old Book Shops

Every student will desire to possess himself of some of the early volumes devoted to the science. Years ago a splendid copy of Robert Hare's brochure on the *Compound Blowpipe* was picked up in an old bookstore for the munificent sum of five cents! The picture of the apparatus was excellent. But the book was carefully laid aside. Its real value at the moment was not appreciated. As the days went on there came to mind that if a question as to the origin of the oxyhydrogen flame should be made, ignorance would be plead, but on turning to the insignificant pamphlet there was the complete story of the oxyhydrogen flame and a fine, understandable account of the unusual things which had been accomplished by means of it. Most textbooks mention the oxyhydrogen flame, its intensity and, meagerly, some of the results of its application. That is all, and yet the story connected with its discovery is at least interesting and may be effectively used with beginners.

A small library of early chemical texts has quietly grown up around the writer of these lines. Every volume has become very precious to him and pages would be required to tell about them. He invariably made it a point as a new number was added to his collection to learn everything possible concerning its contents. Frequently days and weeks were necessary for

this. His early drill in the languages aided him greatly with many of the older books; indeed, the dead languages lost their deadness. However, it is not the purpose to enlarge on this point. The old books are filled with very helpful information. Some may say they are rubbish—nothing more—but he who quietly cons the pages of this musty literature will defend it from any such charge. Indeed, a defence will not be necessary if the object (the book) is read. It is not trash. Many of these treasured volumes are in dilapidated form, but what matters that, so long as their texts are legible. Again, there are others very beautifully printed and bound, the binding itself causing one to pause and admire. But, it is the contents which appeal to the student, as the inquirer will quickly hear on interrogating such scholarly men as Doctors Browne, Newell, Dains, Hopkins, Taggart and Coyle—all of whom, with others, have learned by experience that texts of our science written long ago are worth while and most inspiring. Their own contributions confirm this statement.

While writing this paragraph there came to the desk a copy of Faraday's "Chemical Manipulation," third edition, **1842** (London); so, it is only 83 years old, but how many modern chemists—say since eighteen-seventy—have seen or used it? Its purpose was to aid students in "methods of performing experiments of demonstration or research, with accuracy and success." Much modern apparatus, thought to be products of today or of not long gone days, appears in this book and even in earlier volumes. The student of historical chemistry will desire to read this book, or at least, to leaf it over. There is a much earlier publication (1653)—John French's "Art of Distillation"—in which appear forms of apparatus devised for fractional distillation, strangely similar even in their crudeness, to devices known and used by modern chemists.

But why continue in this vein? Libraries of ancient volumes on our science are the greatest aids and incentives to search further and further into its history.

Collecting as a Hobby

It has been previously stated that autograph letters and pictures or portrait prints of chemists had their place in the pursuit of historical chemistry. One should make such collections and not be deterred from so doing because perhaps a friend, in a thoughtless moment has termed him a "crank" or a "mere collector." As he grows older in the work he smilingly accepts these designations of affection; for he will have learned how deeply the letters and pictures enter into the story he wishes to use in order that facts, apparently difficult to comprehend, may be made intelligible and highly attractive—so attractive as to induce real, genuine thought. In the end our teaching object is to arouse thought, which can be done by an aroused interest.

The teacher who will go to the pains of using, to some extent, the experiences set forth in the paragraphs constituting this article will be rewarded for his efforts.

Personal Anecdotes Valuable

And, then, there have been so many romances, tragedies and comedies all along the line of the development of the science that these may be introduced, here and there, in the course of the expositions of the facts of the science. The life history of Joseph Priestley is crowded with innocent little dots on the Doctor—the discoverer of oxygen, nitrous oxide, nitric oxide, ammonia gas, etc., which mark him as very human, just like the rest of us. For instance

> It is a tradition in the family that Mrs. Priestley once sent her famous husband to market with a large basket and that he so acquitted himself that she never sent him again.

And, doubtless, all have heard of the celebrated painter and etcher, James Abbot McNeil Whistler (1834–1903), who brought glory to his native land through his art. Our science was his *bete noir*, at least his own words indicate this. He had entered West Point, where he remained for three years and then was discharged for deficiency in chemistry; or as he said in after years: "Had silicon been a gas, I would have been a Major General." It appears he was called up for examination in chemistry and given silicon to discuss. When called upon to recite he stated: "I am required to discuss the subject of silicon. Silicon, Sir, is a gas." "That will do, Mr. Whistler," said the professor—and the artist-soldier quickly retired to private life. All such anecdotes help brighten the road to glory.

Philosophy of the History of Chemistry

There may be a feeling that it is the philosophy of the history of chemistry which is desired in our lectures. That comes. It dawns and grows if one studies periods, men of periods, their natural and social environment, the condition of their countries as to their resources, as to their governmental relations, and finally as to their industrial and economic status.

There may be heard a voice from the crowd to the effect that time, time, too much time, is needed for the execution of the lines which have been held up for consideration, so that one can do little else. But everything suggested in the preceding lines may be done in odd—in leisure—moments. All this work may be recreation. Tired of pressing, obligatory duties one may well turn to the history of chemistry for the desired rest and recreation.

And now, finally, having in these pages related the particulars of his own conduct, and his own experiences as well as his conclusions, the writer gladly stops with a quotation often used by Priestley—

Sua narret Ulysses.

TEACHING PRINCIPLES OF ELECTRODEPOSITION*

W. BLUM, CHEMIST, U. S. BUREAU OF STANDARDS, WASHINGTON, D. C.

In recent years there has been a very evident increase in the demand from the electrodeposition industries, for persons qualified for research and control work in electrochemistry. If this demand is to be met, it is desirable not only to conduct advanced courses in electrochemistry, but also to present clearly to general chemistry students, the fundamental principles, and thus to arouse an interest in this promising field.

Need for Better Instruction in Electrodeposition
Potential a Factor of Primary Importance
Singe Potentials
Polarization
Anode and Cathode Efficiencies
Overvoltage
Throwing Power
Nature of Deposit
Conductivity

Need for Better Instruction in Electrodeposition

In the teaching of general or physical chemistry, reference to the electrodeposition of metals is frequently confined to the consideration of Faraday's laws, and to the description of a few processes such as copper refining. In consequence the impression is too often created that the operations of electrodeposition are very simple and scarcely deserve study or consideration. If on the other hand an attempt is made to introduce the conception of potentials and polarization, the subject often becomes veiled in a haze of mystery that may persist even through advanced courses in physical and electrochemistry. With the limited time available in general courses there is usually no opportunity for extended descriptions of electrochemical processes, or for an exhaustive discussion of principles. It is possible, however, to explain and illustrate certain fundamental principles and to convey physical impressions that will persist and will clarify subsequent detailed or mathematical consideration.

It is not the purpose of this paper to present any new principles of electrodeposition or to discuss the subject exhaustively. Instead, an effort will be made to show how the physical significance and the practical applications of well known principles can be explained in simple terms, at least to students in physical chemistry, and even to a considerable extent to those in general chemistry. No references will be given to specific researches, which can be found in the current literature and especially in the Transactions of the American Electrochemical Society.

Potential a Factor of Primary Importance

Faraday's laws relate solely to the current, *i. e.*, the quantity factor, and give no clue to the potentials involved, *i. e.*, the intensity factor. It

* Paper read before the Division of Chemical Education, American Chemical Society, Baltimore, April 9, 1925.

may be readily shown, however, that it is largely the potential relations that determine which of the possible processes will take place, what power will be consumed, and the structure, purity and distribution of the deposited metal. In order to study the potentials involved in electrolysis, it is most convenient to divide the total potential drop in the cell into three parts, *viz.*, (1) the difference in potential between the anode and the solution, (2) the potential drop through the solution, and (3) the difference in potential between the cathode and the solution. The second of these quantities, *i. e.*, the potential drop through the solution, depends only upon the specific resistivity of the solution and the dimensions of the cell. The first and third may be expressed in terms of the single potentials of the electrodes.

Single Potentials

The *single potentials* can be most readily explained by reference to the electrochemical series. The single potential of any metal in a solution is determined by (1) the intrinsic electrolytic solution pressure of that metal (which is influenced to a slight degree by its physical structure), and (2) the concentration, or more strictly speaking, the "activity" of the ions of that metal in the adjacent solution. In order to facilitate comparison, the metals are usually arranged in the order of their potentials when in corresponding environments, *e. g.*, in (often hypothetical) solutions with normal, or in some tables with molal metal ion concentrations. Too frequently, however, it is assumed that the potentials of the metals, and their ability to replace each other are in this same order regardless of the type and concentration of the solutions in which they are immersed. Actually it may be shown that in their respective cyanide solutions, in which the metal-ion concentrations are very low, it is possible for copper to have a more negative potential than zinc and to replace it from such solutions.

In the system adopted by the International Union of Pure and Applied Chemistry and by many technical societies, the single potential of a metal, *i. e.*, the difference in potential between the metal and its solution is given the sign of the metal, thus the normal potential of zinc is —0.76 v. and that of copper is +0.34 v. The change in potential of a metal with a change in metal-ion concentration in the adjacent solution may be computed from the well known Nernst's equation.

$$E = E_0 - \frac{RT}{nF} \ln \frac{1}{C}$$

which at 18°C. becomes

$$E = E_0 - \frac{0.058}{n} \log \frac{1}{C}$$

in which

E = single potential of the metal in a given solution
E_0 = normal potential of that metal
n = valence of the metal
C = concentration (or activity) of the ions of that metal in the given solution.

If the metal-ion concentration of the solution is decreased, the potential of the metal therefore becomes more negative to the extent, at 18°C., of $\frac{58 \text{ millivolts}}{\text{Valence}}$ for each tenfold decrease in metal-ion concentration, and conversely if the metal-ion concentration is increased.

Polarization

If electrolysis is conducted between soluble electrodes of the same metal, *e. g.*, of copper in a copper sulfate solution, the copper salt and copper-ion concentration always decrease in the film of solution adjacent to the cathode and increase in that adjacent to the anode. As a result of these changes in metal-ion concentration the potential of the cathode becomes more negative and that of the anode more positive, *i. e.*, the electrodes become *polarized*.

If we define the *static* or equilibrium potential as the single potential when no current is flowing, and the *dynamic* potential as the single potential when current is flowing at a specified current density, the *polarization* at that current density is the difference between the dynamic and the static potential. If the dynamic potential is more negative than the static, the polarization is *cathodic*, if less negative it is *anodic*. Frequently it is difficult to measure the true static or equilibrium potential, especially of metals such as nickel and iron. Fortunately, however, the dynamic potentials, which are far more significant in electrolysis, can usually be measured in any given cell, with good reproducibility, and the *relative* polarizations can thus be determined. The relations between the static and dynamic potentials of a metal, and the corresponding anodic and cathodic polarizations, are shown for nickel in Fig. 1.

In this figure the static potential of nickel in a particular solution which is N in $NiSO_4$, is assumed to be about —0.26 v., which is 0.03 v. more negative than the normal potential of nickel (—0.23 v). The nickel-ion concentration of this solution would therefore be about 0.1 N. (As above indicated, it is difficult to measure the true static potential of nickel in its solutions.) The curve A represents a typical cathode current density-potential curve for nickel deposition and B a typical anode polarization curve for active nickel. The anodic or cathodic polarization at any specified current density, is equal to the difference between the potentials of the points corresponding to that current density on the appropriate curves, and the equilibrium potential.

The principal factors which tend to counteract the changes in ion concentration at the electrodes and to decrease polarization are dissociation, migration, diffusion, and convection. It is probable that of these factors, convection is generally the most significant, whether produced by changes in temperature or density resulting from electrolysis, or by stirring from evolved gases, or by external agitation. It is possible by sufficiently increasing the convection to greatly decrease the changes in ion concentration

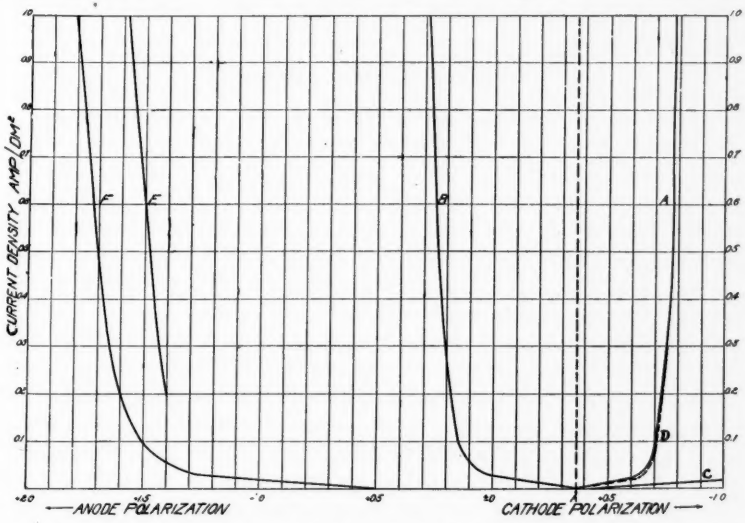

FIG. 1.—Typical electrode potentials during nickel deposition from a solution containing $NiSO_4$—N, NH_4Cl—0.25N, H_3BO_3—0.25M.

A—"Total current density"—cathode potential curve.
C—Curve for hydrogen evolution.
D—Curve for nickel deposition.
B—Current density-anode potential curve for "active" nickel.
E—Current density-anode potential curve for "passive" nickel (In solution containing no chloride).
F—Curve for oxygen evolution on nickel from a nickel solution.

and potential at the electrodes during electrolysis. Even though numerous factors other than a simple change in metal-ion concentration may effect the polarization, it is most convenient to consider the change in potential as equivalent to a corresponding change in metal-ion concentration. At least it is known that all factors which tend to counteract changes in ion concentration at the electrodes, such as agitation or an increase in temperature, decrease the polarization, *i. e.*, make the curves more nearly vertical, and vice versa. Most of the applications of polarization depend directly

upon its relative magnitude, and do not necessarily involve a consideration of its exact causes.

The polarization may be due not only to a change in metal-ion concentration of the adjacent solution, but also to a change in the solution pressure of the cathode. For pure metals, such an effect is usually very slight. However, in alloy deposition, or when hydrogen is discharged simultaneously with a metal, the composition and solution pressure of the cathode may change during electrolysis, and thus may cause an effect upon the polarization.

Anode and Cathode Efficiencies

The potentials at the electrodes during electrolysis also determine the anode and cathode efficiencies, which are often important in electrodeposition. In this connection stress should be laid upon the fact that, in accordance with Faraday's law, the total electrode efficiency is always 100 per cent with respect to all the products of electrolysis, or more strictly speaking, all the changes in valence. From the latter viewpoint, metal deposition consists in the reduction in valence of the metal ions to zero, the valence of all elements in the free state.

As usually defined the cathode efficiency is determined by the proportion of the current used in the discharge of metal. It is frequently, but erroneously, assumed that the tendency for the discharge of hydrogen from any metal salt solution will depend simply upon the relative positions of hydrogen and the metal in the electrochemical series. Obviously this is incorrect, as in a given solution the respective concentrations of hydrogen ions and metal ions are not likely to be normal, or even equivalent to each other. Thus an acid copper plating solution may contain N $CuSO_4$ and N H_2SO_4, but owing to the greater dissociation of the latter compound, the concentration of the hydrogen ions is much greater than that of the copper ions. In a nickel plating solution, however, the $NiSO_4$ content may be N, and the Ni-ion content therefore about 0.1 N, but the hydrogen-ion concentration will usually be much less, *e. g.*, 10^{-6} N or $p_H = 6$. As a first approximation it may be assumed that the initial tendencies for discharge of hydrogen and of the metal will depend upon their respective static potentials *in that solution*.

The actual proportions of metal and of hydrogen discharged at any current density will be determined by the respective current density-potential curves for metal deposition and for hydrogen discharge upon that metal in that solution. Thus in Fig. 1, C represents the curve for hydrogen evolution upon nickel in the electrolysis of the nickel solution used, and D represents the curve for actual nickel deposition. At any given current density the ordinate to A is equal to the sum of those to C and D. The metal cathode efficiency at that current density is equal to the ratio of the

corresponding ordinates to the curves D and A. Under such conditions it is obvious that the nickel cathode efficiency will increase as the current density is increased, but can never reach 100 per cent. If, however, as in acid copper solutions the static potential of the metal is much more positive than that of hydrogen in that solution, the cathode efficiency at low current densities will be 100 per cent and will decrease as the current density is increased.

Overvoltage

The shape of the polarization curves for hydrogen discharge involves the much discussed but still very vague subject of overvoltage. Here again it is more feasible and more useful to explain the nature and application of overvoltage, than to consider intricate theories of its causes.

It is obvious that in order to discharge gaseous hydrogen upon any metal surface, it is necessary to make the potential of the latter at least as negative as that of a reversible hydrogen electrode, *i. e.*, the equilibrium potential of gaseous hydrogen in that solution. It is equally true, however, that if the metal of the cathode, *e. g.*, zinc, has a higher solution pressure than hydrogen in that solution it is also necessary to counteract the tendency of the metal to dissolve, and to replace hydrogen. This requires the application of a potential at least as negative as that of the metal (in this case of zinc). Ordinarily the hydrogen overvoltage is defined as the excess potential beyond that of a reversible hydrogen electrode required to discharge gaseous hydrogen from that solution, either at some minimum current density or at some specified current density. If the latter definition is used, the hydrogen overvoltage is the same as hydrogen "polarization" as above defined. For metals more noble than hydrogen, such as copper, silver and gold, this overvoltage is probably due principally to the concentration and state of the hydrogen in or on the metal. For metals such as tin, lead, nickel and zinc, however, the so-called hydrogen overvoltage is largely a function of the potential of the metal itself.

The potential required to deposit hydrogen with a given current density upon any cathode is a function not only of the metal (as usually emphasized), but also of the hydrogen-ion concentration of the solution, or more strictly speaking, of the cathode film. Hence the cathode efficiency as well as the character of the deposited metal may depend directly upon the hydrogen-ion concentration of the solution. In nickel deposition the p_H of the solution probably has a greater effect than that of any other factor.

Similarly the metal anode efficiency is determined by the respective polarization curves for metal solution and for oxygen evolution, which latter is influenced by oxygen "overvoltage." With metals such as nickel, anode polarization is affected by "passivity," *i. e.*, the tendency of the metal to assume an abnormally positive potential. In Fig. 1, curve F

represents oxygen evolution upon nickel from a nickel sulfate solution. If the nickel becomes passive, as represented by the curve *E*, it is obvious that the anode efficiency will be lowered by the simultaneous evolution of oxygen.

Throwing Power

The importance of cathode polarization curves in electrodeposition may be illustrated by the fact that they largely determine the current and metal distribution upon a cathode of irregular shape. From their study it is often possible to predict the effect of a given change in conditions upon what the plater calls "throwing power," *i. e.*, the power to deposit metal in recessed portions of a cathode. In general, high cathode polarization is favorable to throwing power as under such conditions it is relatively easier to deposit metal at a low current density, *i. e.*, on remote parts of the

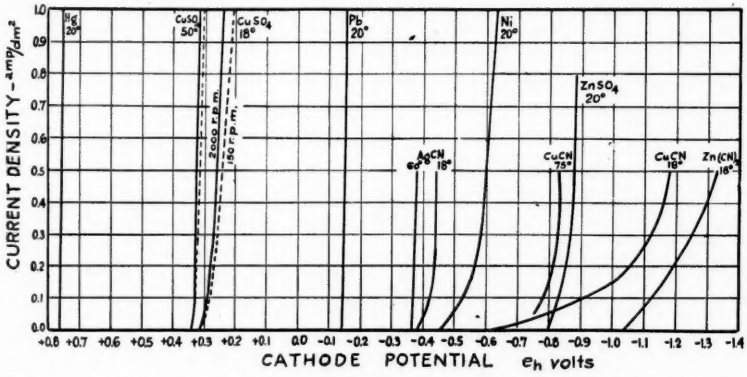

FIG. 2.—Typical current density-cathode potential curves. Derived from Foerster—"Elektrochemie Wässeriger Lösungen." 1922.

cathode, than if there were no polarization. Solutions containing complex salts, such as the double cyanide solutions of copper and of zinc, have very low metal-ion concentrations and hence high cathode polarizations. Such solutions therefore possess better throwing power than the solutions of the simpler metal salts such as copper or zinc sulfate.

In Fig. 2, representing typical cathode polarization curves, it may be seen that in simple salt solutions of lead there is very little polarization; in zinc and copper sulfate solutions there is more polarization; and in their cyanide solutions there is marked polarization. The throwing power of these solutions varies almost directly with their polarization.

Nature of Deposit

It has also been found that the cathode polarization largely determines the size and character of the crystals in the metal deposit, which in turn

govern many of its physical properties. A small crystal must have a higher solution pressure than a large crystal. Hence it requires a higher polarization (a more negative cathode potential) to discharge metal ions to form a new crystal than to continue the growth of an existing crystal. Therefore we can predict that the average crystal size will be smaller with high than with low polarization. Actually we find that deposits from cyanide solutions are much finer grained than those from the sulfate solutions, for the reasons given above; and that crystals formed from a solution at a high current density are smaller than those at a low current density.

Conductivity

The *conductivity* of the solutions used in electrolytic refining is of course important, as it largely determines the power cost. In electroplating and electroforming, however, the power consumption is usually a relatively small item, and conductivity would not be important from that standpoint. In general, however, good conductivity is desirable because it improves the throwing power (provided there is appreciable polarization), and it also leads to the formation of smoother deposits.

I am indebted to my colleague, Mr. H. E. Haring for an ingenious method not previously published, for illustrating graphically what becomes of the total voltage applied to any bath during electrolysis. In Fig. 3 the conditions are represented when current is passed between two plane parallel nickel electrodes, each 10 cm. square, and 10 cm. apart. The solid lines represent the behavior of one nickel plating solution, designated for comparison as "standard," and the dotted lines that of a nickel solution containing in addition a high concentration of sodium sulfate such as has been recently found useful for nickel plating on zinc.

The space between the lines AB and AC, represents the IR drop through the cell considered, for the standard solution at any given current density. The slope of the straight lines AB and AC is determined solely by the specific resistivity of the solution. Thus if the standard solution has a specific resistivity at 25°C. of 20 ohm-cm., there will be in this cell, an IR drop of 2 v. at 1 amp./dm.^{2}, 4 v. at 2 amp./dm.^{2}, etc.

The curves AD and AE represent the anode and cathode polarization curves in the standard solution. They start at the point A, *i. e.*, the static potential of nickel in that solution, and at each current density the polarization is plotted, not as in the previous diagrams from a vertical line corresponding to the static potential, but from the lines which represent the limits of the IR drop in that solution. The dotted lines correspond to the "high-sulfate" solution, of which the specific resistivity at 20°C. is about 9 ohm-cm., *i. e.*, much lower than that of the standards; but in which both the anode and cathode polarizations are greater than the standard.

From this diagram it may be seen that to produce given current densities (in the cell represented) it is necessary to use certain total voltages,

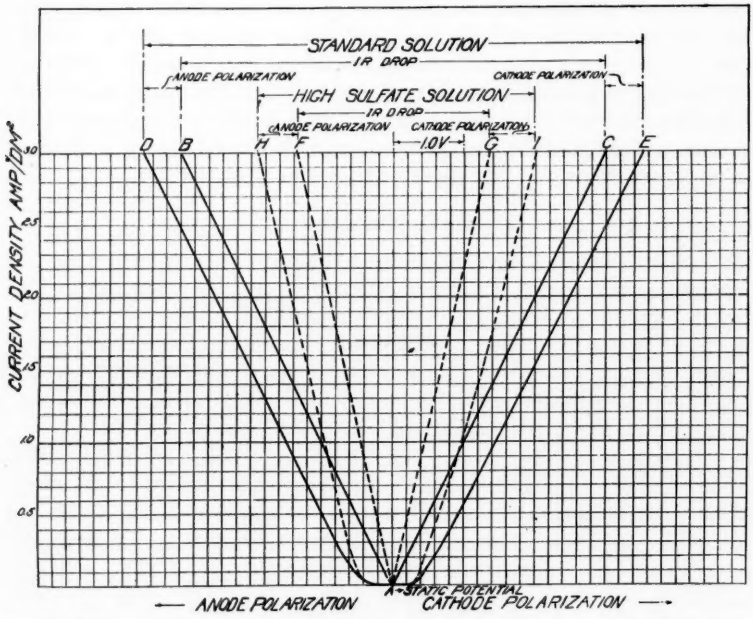

FIG. 3.—Diagrammatic representation of total potential drop during electrodeposition of nickel.

(1) Solid lines for solution containing $NiSO_4$—N, NH_4Cl—$0.25N$, H_3BO_3—$0.25M$.
(2) Dotted lines for solution with the same constituents in (1) plus Na_2SO_4—$3N$.
AB and *AC*, limits of *IR* drop in solution (1).
AE—Cathode polarization in solution (1).
AD—Anode polarization in solution (1).
AF and *AG*, limits of *IR* drop in solution (2).
AI—Cathode polarization in solution (2).
AH—Anode polarization in solution (2).

each of which consists of anode polarization, cathode polarization and *IR* drop, as shown in Table I.

TABLE I—POTENTIALS (VOLTS) USED DURING ELECTROLYSIS

C.d. amp./dm.²	Standard				High-sulfate			
	Anode	*IR*	Cathode	Total	Anode	*IR*	Cathode	Total
0.2	0.46	0.40	0.38	1.24	0.46	0.18	0.38	1.02
0.5	0.49	1.00	0.43	1.92	0.50	0.45	0.43	1.38
1	0.50	2.00	0.45	2.95	0.52	0.90	0.52	1.94
2	0.51	4.00	0.48	4.99	0.54	1.80	0.62	2.96
3	0.52	6.00	0.52	7.04	0.55	2.70	0.65	3.90

From such a figure we can readily see that for solutions such as those of nickel, in which there is marked polarization at low current densities, the greatest *relative* deviation from Ohm's law in the behavior of the cell as a whole, occurs not at high but at low current densities. In all solutions, polarization tends to approach a maximum as the current density is increased and therefore at the higher current densities the total potential drop in the cell is more largely determined by the resistivity of the solution than at low current densities.

It is hoped that by some such simple methods as are illustrated in this paper it may be possible to inculcate early in the technical courses those fundamental principles of electrodeposition, upon which any sound exhaustive or mathematical treatment of the subject must rest.

James Douglas Medal. William H. Bassett, technical superintendent and metallurgist for the American Brass Company, Waterbury, Conn., has been awarded the James Douglas Medal for distinguished achievement in non-ferrous metallurgy.

This medal is bestowed annually as a memorial to Dr. James Douglas, formerly president of the American Institute of Mining and Metallurgical Engineers.—*The Technology Review.*

School and Society announces that the sum of $8000 has been entrusted to the American Council on Education to provide for scholarships for study abroad during the year 1925–26, each worth $1000. To be eligible to receive one of these scholarships a student, either man or woman, must be not less than eighteen years of age, must have been in residence for a period of two academic years at an American institution approved by the American Council on Education, and must expect to return to his American College to take his degree. There is no limitation concerning the countries or Universities in which students may study, or to the field of study. A program will be so arranged that full credit for the work of the year will make it possible for the student on his return to his American College to pursue his course regularly with his class.

Department Chemists Help Dye Industry. The discoveries of the chemists employed in the color laboratory of the Bureau of Chemistry of the department have been an important factor in freeing the millions of cotton users in America from foreign domination of fadeless dyes, according to a report read at a recent meeting of the American Chemical Society by R. Norris Shreve, of New York, chairman of the division of dye chemistry of the chemical society.

Dye intermediates, the report declares, are now being produced in the United States at prices below their cost in Germany. Savings aggregating millions of dollars to users of cotton fabrics have resulted from the development of cheaper intermediates for dye manufacture. These intermediates particularly necessary for the vat dyes are, it is said, actually being exported to Europe.

Permanent Colors Now Available. "The American manufacturers of vat dyes," says the report, "now have at their disposal cheap and pure products with which to build up the complex molecules characteristic of these colors, which give the brightest shades and the most permanent colors yet made. Every household in the land has been affected by this change.

"The rapidly fading colors of 1916 and 1917 and the waste entailed in replacement cost for clothes and draperies have given way to sun-fast, no-fade clothes and materials.

"These are possible," the report adds, "because of the vat dyes, and the American vat dyes are with us because of the development of cheap aluminum chloride and phthalic anhydride."

The process for making phthalic anhydride was worked out in the Color Laboratory of the Bureau of Chemistry. This laboratory was organized in 1916 to assist in the development of an American dye industry. The need for such an industry was never fully appreciated until the European war cut off this country from its German supply of intermediates. More than twenty processes for making intermediates and other products used in the dye industry have been developed, patented, and dedicated to the public by the staff of the Color Laboratory. The taking out of a public service patent on a process insures that the process may not thereafter be used for the exclusive benefit of one person or one concern.

Phthalic anhydride, which was previously obtained only from Germany, is used in the manufacture of more than 300 different dyes, drugs, and chemicals.

The United States now produces about 96 per cent of the dyes used in this country.—*The Official Record of the U. S. Dept. of Agr.*

CORRELATION OF LECTURE, RECITATION AND LABORATORY WORK IN GENERAL CHEMISTRY*

C. A. BRAUTLECHT, UNIVERSITY OF MAINE, ORONO, MAINE

General Attitude of Students
Attitude of Teachers
Approaching the Subject
Lecture-Test Periods
Recitations
Correlation of Lecture and Recitation
Laboratory Work
Note Book Inspections
Make-Up Periods
Test Grades
Record Sheets
Examinations
Relative Values for Different Parts of the Pupil's Record

General Attitude of Students

At the present time when there is so much thought given to obtaining "easy money," to getting big pay for little work, and to indulgence in much pleasure, it is not surprising that many pupils in our chemistry classes desire chiefly to be entertained and then, at the end of a course, given a statement that they are familiar with the fundamentals of the subject. Such seems to be the spirit of the times, and upon analysis of the situation we cannot assign responsibility to political, social, economic, athletic or cinematographic conditions, exclusively.

Pres. H. N. MacCracken of Vassar College states in his last annual report that, "The restlessness of the American college student is then an echo of the restlessness of the world at large." Many officials in educational institutions and many people in other walks of life are asking the question, "What is the matter with chemistry in our high schools and colleges?"

How can we meet the desire for a smattering of many subjects and the mastery of the fundamentals of none? How can we aid the pupils in our high-school and college courses in general chemistry to acquire the ability for hard mental work in which scientific chemistry from its very nature can be so helpful? How can we help them to obtain a thinking acquaintance with matter? It is with the hope that a few ideas regarding correlation of parts of the subject may be helpful to our young teachers, that the following statements are made.

Attitude of Teachers

Many chemistry teachers, with varying qualifications and interests, drift along in the assurance that chemistry is taught as well as the average subject. I thoroughly believe that it is. Do we, however, give sufficient thought to how much our students learn? Have they any ideas of matter from the viewpoint of scientific accuracy, quality, quantity, and economy factors? Do we realize that much elementary chemistry study today is beginning to get the reputation that physics, although an excellent sub-

* Paper read before the Division of Chemical Education, American Chemical Society, Baltimore, April 8, 1925.

ject, has and that chemistry is now often taken only as a required subject? Do we ever stop to consider the size of our textbooks and the quantity of extra- and intra-curricular activities which compete for the student's time? Are we holding the student and the pupil up to a minimum standard, even if it is below what we feel the standard should be? Are we making a conscientious effort to help the young people in our classes? Do we automatically stamp a note book containing a pupil's observations and expressions without reading a sentence or looking at an equation? Do we have students take written tests and then without inspection throw the papers in the waste basket? If so, it were better never to have a written test. Is it not high time to reflect a little on measurement of the knowledge of the subject which the pupil acquires?

Approaching the Subject

When our course starts, what shall we tell our classes? Experience has led some teachers to tell their classes that they have an opportunty, nothing more, to acquire some knowledge of chemistry. They are told as briefly as possible what chemistry is and what a knowledge of it will mean to them. They are also informed very clearly that they will get nothing or little out of the class work unless they put something in. That something is the interest and will to study the assigned work.

A satisfactory procedure in presenting the subject, recording the information obtained concerning pupils' abilities and reporting the same is outlined herewith. Students are informed that their laboratory, lecture-test and recitation grades are correlated and that one part of the subject supplements the other two. They are informed that study does not mean one hurried reading of a text assignment and that about two hours are needed for preparing each lecture-test and recitation assignment.

Lecture-Test Periods

The meaning of tests is stated and the procedure employed in preparing, marking and discussing tests is illustrated. In this manner the pupil knows what is expected of him and that he must be prepared to give information on a time-limit basis. Students today need drill in acquiring a sense of economy in time and money. The test questions, problems, etc., are always based on fundamental topics and capable of rapid and accurate marking on a point basis, the denominator representing the value of the question, problem, etc., and the numerator indicating the value obtained. Students take a marked interest in this type of detailed grading. The papers are recorded in the department office, returned to the student during the next lecture period, and discussed. Taking twenty-five minutes for a written test or test discussion each week allows for three or four tests during a half-semester or quarter. Twenty-five minutes de-

voted to lectures weekly (at one sitting) is about as long a time as the average present-day pupil can concentrate his attention. The average lecturer, of course, feels that he needs a full hour and often more to present the topics for the day properly. It therefore becomes necessary to concentrate on the most important topics during the time allowed, with experimental demonstrations ready to "set off." By recording the test grades on tabulation sheets, one makes it a simple matter to compare the grade of any student with the average, minimum, and maximum grade for the class. The average test figure for a division indicates much about the relative difficulty or simplicity of a test. Test records also yield much information about the work of individual pupils. A student whose test grades are always low may lack the necessary ability to do the work, may be indolent, or may lack interest. A student with uniformly high grades is a consistent worker. Some who have both high and low grades are found to study irregularly. If the average test grade for a student was high, and either the recitation grade for the quarter or the laboratory grade for the quarter was low, the student's work and record is carefully investigated. This variation rarely occurs, and analysis of individual cases leads to a satisfactory explanation. If a student or pupil misses one or more tests, he is given one opportunity, on a specified evening, after the last test for the quarter, to make up tests, using a test make-up card. The teacher in charge of the make-up period grades the papers and submits the grades to the department office for recording. If no make-up test is taken, the student receives a zero for the missed test and this is included in determining the average test grade.

In examining the written work of a student, it should always be checked in a contrasting color. This is necessary if the inspection is to mean something definite to the teacher and student. The term "grading" should be used instead of "correcting," as "grading" more nearly expresses what is done.

With a rotation of test papers among different graders, the judgment of different instructors is recorded, which is, again, information well worth having on record. Examination of the test-record sheets indicates the pupils who need observation and warning before the course has progressed so far that a warning will do little good.

Recitations

In conducting a recitation on the basis of assignments made at the beginning of a quarter and announced during a lecture period, it becomes very desirable to have a lesson plan, in order that the essential topics may be considered first and the time divided to obtain blackboard and oral quiz work to the best advantage. The correlation of the facts which are known to the pupil with new topics must be left to the individual instructor.

To maintain the pupil's interest, to afford a reasonable opportunity to ask questions relevant to the subject, etc., are matters of judgment with the individual instructors. Questions asked of class members must never be repeated. If a student is not attentive he must be penalized, otherwise discipline cannot be maintained. Efforts at irrelevant discussion and monopolizing of time or argumentation have no place and must be ignored or prevented. The recitation procedure must be varied, and the more variation introduced in the lesson plan, the greater will be the interest. In asking questions, it is the best policy to state the question and then allow a brief pause, with the class uncertain as to who will be called. When time is very limited, "yes or no," or "true or false" answers can be employed, in part.

With the lecture and laboratory work to outline and demonstrate the essentials of a topic, with the recitation to develop and drill it, with the test to determine if the important facts have been learned and understood, and with the test discussion to point out and rectify errors, little more can be done. The pupil has had his chance; he has been instructed, and, if he spent a reasonable amount of time in study, he acquired something. Most details, if he does not use them, will soon be lost. The habit of thinking about matter and its changes will be retained, however, and details can be recalled when occasion requires. Thus the student's work becomes a permanent asset.

Correlation of Lecture and Recitation

It is a simple matter to correlate lecture, recitation, and test work. With recitation and laboratory assignments planned roughly at the beginning of the year, but assigned at the beginning of a quarter, adjustments can easily be made for emergencies. In general it is necessary to keep sections of a division on the same work for the week or half-week. In considering the question as to whether or not laboratory work should parallel, succeed or precede lectures and recitations, the writer's experience with groups of 300–500 general chemistry students has been that, at first, the laboratory work should precede recitations and parallel lectures. Later, near the end of the first quarter and for the remainder of the course, this is not necessary. Some topics require considerable time for recitations and little for such laboratory work as can be done efficiently. An effort to hold recitation and laboratory work parallel during the second half of the average course usually fails.

Shall laboratory work be recorded separately for registrars and other officials or shall it be reported under the general subject head? Both procedures are employed extensively. After experimentation with both, the writer is convinced that the department records should show laboratory, lecture-test and recitation grades in detail, but that in registration and

reporting, the subject should be considered as a unit. Needless clerical work occurs with a separation of the subject into parts in a final statement, and the student may think in terms of fragments instead of the whole. Then, also, we meet with the unsatisfactory condition of a student failing one part of the work and passing the other. This happens quite often where different instructors have absolute charge of separate parts of the work. The question also arises, whether we are not likely to obtain poorer results with many subjects registered than when closely associated parts of a subject are considered together as a unit.

Laboratory Work

In laboratory work, the student has his best opportunity to acquire the first-hand information needed concerning solid, liquid, and gaseous substances, elements, compounds, and mixtures, lasting changes of matter and evidences thereof. Observation of pupils who have had laboratory work only and others who have had lectures and recitation work only, shows that the former have what might be called chemical sense; the latter have not. The contact with the substances themselves makes the strongest impression. On observing a group of pupils about to begin a study of chemistry for the first time, it is soon evident that their chief interest is in laboratory work. This interest can only be maintained by a logical development, and the pupil needs constant supervision. With groups of sixteen to twenty pupils, any instructor should be able to know what each pupil is doing and how well he is performing his assigned experiments, at the same time keeping an eye on side tables and sinks.

Note Book Inspections

How note book inspections can best be conducted is a problem that confronts every conscientious teacher. Where two laboratory periods are held weekly, note books may be collected at the end of the first period and some examination of the work of the week made. Leaving them with the pupils after the second period (over the week end) will give good results. Students should be encouraged to reflect a little upon their lecture notes, and laboratory observations, and the instructor's red-ink notations thereon. They should likewise have an opportunity to compare their observations with the statements in the text. To obtain good laboratory work it is necessary to have pupils bring and use their texts for reference. Even a busy instructor can select certain parts of each week's work and examine them. For instance, one page of equations, and notes for one experiment may be graded. At the end of a quarter, the grading for five pages will be representive of the grade for the entire note book.

To get the value out of laboratory instruction that we should, it is really necessary to have one hour of laboratory instruction yield one teacher-

credit hour. At present this is rarely, if ever, done. For a pupil, two hours of laboratory work properly yields one credit hour. One reason why many laboratory instructors cut corners is that they are convinced that instructors in other subjects do not work as many hours per week on their class work.

Recording of technique grades, laboratory note grades, and daily grades for recitations and outside written work in fixed places in the instructor's record book, and finally filing of these in the department office make it possible to look up details concerning past classes. With the use of the summary records described hereafter, this is, however, rarely necessary.

Make-Up Periods

One evil in much laboratory work is that some pupils may be absent quite often and miss considerable work and still obtain a passing or even as high a grade as students of equal ability who have missed no work. The making up of missed work in a large high school or college is a problem of great magnitude. An instructor cannot be expected to work overtime whenever pupils desire to make up missed work, if this is required. The procedure outlined below has worked very satisfactorily with general chemistry classes totalling from three hundred to five hundred students. A student, absent for any reason whatever, is reported as deficient in the department records and to the registrar, for the number of laboratory periods missed. He obtains no grade until the deficiency is made up. The instructors' records of total absences are filed immediately after the last laboratory period, before equipment is checked in. The pupils are notified of deficiencies to the date of the notice. Simultaneously, there is posted a notice of a make-up period at a certain time. This may be during an evening, late in an afternoon, or at some other time when the majority of the pupils would have no classes. The student obtains from the storeroom a laboratory make-up card for each period missed, at a fixed charge of twenty-five cents per card. Each card entitles him to a two-hour laboratory period with supervision. The card is signed with his name, and, at the end of the period, the instructor in charge signs the card if the work is properly done. The make-up instructor furnishes directions taken from partly used, unclaimed manuals, for experiments for which supplies are available, or issues unknown samples for testing. These are for the student who appears with notes written up and who has not enough work to do. The pupil may have made up missed experiments during the latter part of regular periods or even copied some notes. At the end of the make-up period, the instructor leaves the cards in the department office, where they are filed. At the end of the half-year or semester, the pupils having cards are given credit for the number of periods made up, which usually checks with the number of absences reported. On evenings, two

make-up periods are held. As equipment is held for a few days after the last regular laboratory work is completed, most of the make-up periods occur then. The make-up card stub from the storeroom makes possible an additional check on pupils buying cards and money taken in. Any deficiencies not made up during the semester in which they occur are carried over until the work is next repeated. Only in a very few cases will a pupil leave them until a later semester. Such pupils obtain temporary sets of equipment from the storeroom. The make-up instructor receives a fixed sum for conducting make-up work. It is not hard work, as only in a few instances will there be a large attendance. There may be some who think that this charge is not good ethics or is unreasonable. However, department funds cannot be taken for this purpose. The opportunity has been given the student and he has not utilized it. There is no effort to make money. The pupil wants the grade and it is worth getting. For two years the experiment of giving pupils who had excused absences free make-up cards of another color was tried by the writer. Almost all of the pupils then had excuse cards, the number of absences was much greater, and sales of cards did not yield enough revenue to pay the make-up work instructors. On the paid make-up card system, however, as an example of attendance and make-up work for a division of eighty pupils during a semester, there was a total of 49 periods missed by 31 pupils. All but two of these made up their deficiencies before the end of the semester. Of these 31 pupils, sixteen had only one deficiency. Other divisions had similar records.

Test Grades

Some of the figures for one division for four tests in the second quarter of a semester were, respectively: average, 48, 82, 87, 68; minimum, 11, 55, 52, 48; maximum, 95, 100, 100, 100. Marked on a point system, it was possible for a pupil to obtain anything from 0 to 100. The first test was apparently a difficult one and the next two were intentionally made easier in order that pupils would not become discouraged. Thus the test average to date, after the second, third, and fourth tests, was, respectively, 65, 72, 71. Comparing the figures with the recitation average for the same group, 69, and with the laboratory grade, 75, the half-semester figures for this group were reasonable and the figure for each student was a just one. The first half-semester figures for the same group were similar. Where pupils being trained on the basis of routine of the same ideas and facts, the figures would be much better for the second half, but where the student never repeats the same lessons and must constantly learn new ones, the average grade may be about the same for quarters or half-semesters. Similar to the second half, the first half-semester grades are based on the average of the test averages, recitation, and laboratory grades. To ob-

tain semester grades, the first half, second half, and examination grades are added and divided by three. For one section, grades for the second semester were as follows: first half, 74, second half, 72, examination, 67, semester average, 71.

Record Sheets

In preparation of the record sheets (size 8.5 × 11 in.), names of pupils are taken from index cards passed to the assembled classes, full names being printed and other information stated. These cards are compared with enrolment cards, and discrepancies checked, and then arranged alphabetically and typewritten on a ruled department summary record sheet. By use of carbon paper, a second impression of them is obtained on a second ruled sheet, which becomes the test record sheet. Third and fourth impressions are obtained upon blank sheets, which are used in reporting grades to the registrar. Changes on the summary sheet regarding name, dropping of a pupil, etc., are made on each set. In this manner there is almost no chance for error. The headings with three typical examples for the two kinds of records are on the following page.

Examinations

In making out examinations the same procedure is employed as in tests, the only difference being that there is more time and a much wider range of topics, and many factors with small numerical grade values. For instance, one part of the examination paper may call for five definitions, each with a grading value of two units. The pupil gets the definition or he does not, and the grader can quickly and accurately mark such parts of the paper 0/10, 2/10, 10/10. The examination books are graded in red ink or pencil and remain as evidence in the department. Studies of marking by different graders on the above point system show that there is no appreciable variations in grades. In one study, five graders marked and reported the values on slips of paper for twenty examination books, selected at random, the examination being of the general type with no effort made to select questions, statements, and problems which were especially easy to mark. The values as reported did not show a variation of five per cent.

Relative Values for Different Parts of the Pupil's Record

The average of the laboratory grade, recitation grade and test-average grade yields a figure which is a fair indication of a pupil's absolute and relative ability in the subject. Careful marking of the same ten or even five per cent of the pupil's notes, if they are extensive, will yield results on a point basis in close agreement with results of inspection of a larger part the notes.

The test of any correlation procedure from the viewpoint of efficiency is whether or not it yields information that is necessary and whether the

Section Name in full	Test No. Date	1 0.8	2 0.22	3 N.5	Test Av.	Rec. Grade	Lab. Grade	4 N.19	5 D.3	6 D.17	7 J14	Test Av.	Rec. Grade	Lab. Grade
Parker, Albert Marcus		75	90	91	85	90	85	94	80	85	94	88	86	80
Scribner, George Frederick		70	60	70	67	60	70	65	66	75	59	66	70	80
Cram, Kenneth David		70	55	53	59	86	73	64	46	85	62	64	75	88

Section Name in full	School	Preparation Teacher	Text	Entr. Exam.	Lec. Seats	Absences 1st half	2nd half	Rec. Sec.	Lab. Sec.	Grades 1st half	2nd half	Exam.	Sem. Grade	Lab. periods Missed	Made-up
		No ch.	..	..	R			402A	IV						
Parker, Albert Marcus	Bordentown				E				203	87	85	79	84	0	0
	Mt. Inst.	..	..	..	5			Go	Cu						
			?	5	R			301	V						
Scribner, George Frederick....	Oakland				F				203	66	72	58	65	1	1
	H. S.				9			CB	Go						
		H.M.	B		L		D. 10	137	II						
Cram, Kenneth David	Gardiner		&	25	G				203	73	76	64	71	1	1
	H. S.	F...	C		1			P.B.	Li						

cost of this information in time and money is reasonable. The first point is easily answered in the affirmative. The pupil also feels that he has had a square deal. He knows that the array of evidence permits of little misinterpretation. The pupil who fails does so automatically by his record, based upon the judgment of more than one person. At a staff meeting held shortly after semester examinations, the name and semester grade of each student is read. If any instructor questions this grade, the half-semester and examination grades are stated. (The average figures for the division are kept evident.) If there is still any question, the detailed quarter grades are stated. There is a feeling on the part of all staff members that a satisfactory piece of grading has been done and that the figures mean something definite. Grades in figures can be given letter values, if there be need to do this, so that there may be a correlation between the pupil's chemistry grade and his grade in other subjects. A little flexibility here may be very desirable. It is possible that conditions may have been exceptionally favorable to good work and that a grade below 60 on a hundred basis should represent a failure. On the average, it is safe to assume that a pupil receiving below 50 on an attainable 100 basis is a failure in the subject. The policy of calling the lowest fifth or other proportion of a class failures is poor policy. Likewise selection of a fixed proportion of a class as of honor grade is unwise. Classes will vary in ability, and one class may average ten per cent higher than another on the same work under practically the same conditions.

One might judge that the cost of the correlation procedure outlined would be very large. Not at all. The ruled sheets are inexpensive. Listing of names by a clerk or even by a student assistant, using carbon duplicates, for four purposes, is economical in time. The recording and averaging can be done in a short time. A grade is reported promptly for every pupil enrolled, which is also a great saving of time to the staff members.

College Students Prefer Fairness to Brains. The college instructor who would be popular with students need not thrill them with his brilliance, but he must be fair in grading and courteous, according to a test made with 40 seniors at Purdue University. Tact, sympathy, and cooperation are the qualities which the students regarded as most essential to popularity.

Prof. George C. Brandenberg, who reports the results of these tests in a coming issue of the *Journal of Applied Psychology* expresses surprise that the students do not demand intellectuality in an instructor as one of the first desirable qualities. But he concludes that "after all, students are only human and apparently crave first the same humane qualities in their instructor that they demand in their classmates."

The ten qualities most agreeable in an instructor were rated by the students in the following order: honesty and fairness in grading, courtesy and consideration, liberal and progressive attitude, cheerfulness, clearness, punctuality, generosity, cleanliness and neatness, morality, intellectuality.

The students held that the ten most disagreeable traits an instructor can have, in order of their importance, are: lack of courtesy in the classroom, unfair practices in grading, disagreeable qualities of disposition, egotism, irritating personal habits and peculiarities, lack of cordiality, lack of punctuality, lack of dependability, lack of public spirit, and untidiness in dress.—*Science Service.*

APPLICATION OF THE ELECTRON CONCEPT TO OXIDATION-REDUCTION REACTIONS IN GENERAL CHEMISTRY*

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The modern idea of the structure of the atom has received little serious attention from teachers of General Chemistry. It is frequently mentioned in some part of the course, but in such a manner that the student has little opportunity to apply the concepts which are involved in this hypothesis. When introduced in this manner it is merely another theory which the student has to learn and for which he sees no use. The concepts which are involved in the theory of atomic structure are beginning to reach the stage where they are taken for granted and the indications are that its assumptions are, in their present form, substantially correct. One is reminded of the development of the theory of electrolytic dissociation. At first its assumptions were ignored, then they were introduced into some of the courses by amused skeptics, and finally they were accepted and they constitute today the most useful of all the theoretical assumptions for securing a systematic presentation of the chemistry of the acids, bases, and salts.

Electron Concept Easily Assimilated by Students
Application of the Electron Concept
Valence in Terms of Electrons
Oxidation-Reduction Reactions
Ionic Replacement an Oxidation-Reduction Phenomenon
Compensating Valence Changes
Advantages of the Electron Concept

It is not the purpose of this paper to enter into a discussion of the basis upon which the modern idea of atomic structure rests; but rather to indicate some of the applications of this idea to the reactions involved in a course in general chemistry.

Electron Concept Easily Assimilated by Students

The theory is one which can be made very interesting to the students. It appeals to their imagination and little difficulty is experienced in getting them to learn and accept this idea of the atom. The application of the assumptions of the theory affords a much more simple and logical method of attack in the study of all reactions which involve valence changes than do the methods which are now being generally used. When interpreted in the light of this theory, all such reactions involve the same kind of change, for valence changes are due to the transfer of one or more electrons from one atom to another. From this point of view, reactions of direct union; the displacement of ions from solution, both by elementary substances and by the electric current; and oxidation, whether it involves adding oxygen, removing hydrogen, or neither, are all the same kind of reaction.

Those of us, who for years have used the "step equation method" for

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deriving the equations which represent complicated oxidation-reduction reactions, at first find the electronic method somewhat difficult. We have gotten into a habit of thought such that the mention of oxidation by a compound substance causes us to think at once of "nascent oxygen." Similarly, in the more complicated equations for reduction reactions, we use a concept of "nascent hydrogen." We then assume various intermediate products and finally arrive at the only significant equation, the one which represents the actual products, by adding a series of partial equations and cancelling those substances which are common to both sides of the equations. The shift from this point of view involves breaking this train of thought and substituting for it a new method of attack. For the beginner, however, this is not the case for the whole subject is new and he has no method already thoroughly developed.

Application of the Electron Concept

It will be obviously impossible to trace the gradual development of the method for to do so would involve virtually the whole of a course in general chemistry. The scope of this paper makes it possible to show only a few of the applications of the method. The whole subject of valence can be made more simple and logical in the light of the electron concept than in any other manner. The application of this concept to reactions which involve valence changes, *i. e.*, oxidation-reduction reactions, will be discussed. The method which has been found to work best in classroom use, for deriving the equations which represent such reactions, will be illustrated by several examples.

Valence in Terms of Electrons

The whole subject of valence is one which is always puzzling to the beginner and it is very difficult for him to express in words just what this word signifies to him. Valence is usually regarded to be a combining capacity of the atom or of the atomic weight of an element in terms of atoms or atomic weights of hydrogen. These words mean little to the beginning student. When he calculates from the analytical data the atomic ratio of the elements in various compounds, he secures the simplest formulas which represent these compounds. Assigning to the atom of hydrogen a valence of one, the valences of the other atoms in terms of hydrogen are obtained. In this manner we find that sodium, potassium, chlorine, and bromine all have a valence of one in their binary compounds. Now, a fact which confuses the beginner is that sodium and potassium can be used interchangeably in compounds as can also chlorine and bromine, but sodium cannot be substituted for chlorine nor can potassium be substituted for bromine although all these elements have a valence of one. A little further in the course, the student finds that chlorine has a valence of

one in hydrochloric acid and also a valence of one in hypochlorous acid. Yet he is told that hydrochloric acid must be oxidized and hypochlorous acid must be reduced in order to obtain free chlorine. The result is that the student becomes confused and it is difficult to have him understand why two elements of the same valence capacity do not show the same kind of combination reactions.

In the light of atomic structure these difficulties can be easily cleared up. The student has been taught from the beginning of the course to consider that the atom is a complex body which consists of a positively charged nucleus with a number of electrons about it, the number of electrons being equal to the number of free positive charges in the nucleus. Certain numbers of electrons result in stable configurations so that atoms such as those of the inert gases are not reactive. In all other cases, except the inert gases, there is an incomplete outer shell of electrons and the elementary substances react so as to lose or gain electrons and approach the stable arrangement of an inert gas. The atom of sodium, whose atomic number is 11, is assumed to have an inner shell of 2 electrons, a second complete shell of 8, with the remaining electron in an incomplete outer shell. This outer shell electron is the valence electron which is readily given up to some other atom during direct union. Sodium is now left with a positive charge of one because there are 11 free protons in its nucleus, but only 10 electrons about it. The atom of potassium is of a similar structure, except that there is another complete shell of electrons before the incomplete shell in which, however, there is only one electron. The atoms of other metals, in general, contain a small number of electrons in the outer ring. Their reaction tendency is to lose electrons and they are thus left positively charged. The atom of chlorine, whose atomic number is 17, has 7 electrons in its outer shell. It lacks only one electron of having a stable arrangement and its major reaction tendency is to gain this additional electron. Having done so, it now has 18 electrons about a nucleus which contains only 17 free protons. The atom of chlorine in the chlorides is therefore in a negative condition.

Valence refers to the condition of the atom of an element when in combination. Elementary substances are in a zero valence condition. Valence may be either positive or negative depending on whether the atom has gained or lost electrons in its reactions. The positive valence of an element is equal to the number of electrons which its atom has lost. The negative valence is equal to the number of electrons gained by the atom of an element. Sodium and chlorine cannot be used interchangeably in compounds because they do not have the same valence although the valence of each is one. The sodium atom exhibits a great tendency to lose an electron while the chlorine atom shows little tendency to do so in reactions of direct union. Another example which may be used to illustrate the subject of pos-

itive and negative valences is the case of nitrogen. The atomic number of nitrogen is 7 and there are five electrons in its incomplete outer shell. A more stable configuration is reached, either by the gain of three electrons to bring this outer shell up to a stable eight, or by the loss of five electrons so as to drop to the stable arrangement shown by the helium atom. Hence we find the most stable compounds containing nitrogen to be the ammonium salts in which it exhibits a negative valence of three and the nitrates in which its valence is five, positive. The relation of the electron to valence is of fundamental importance in applying the electron concept to oxidation-reduction reactions.

Oxidation-Reduction Reactions

The interpretation of oxidation-reduction reactions in the light of atomic structure must be very gradually introduced. Class-room experience indicates that it is unnecessarily confusing to the student to develop first the idea of oxidation as the addition of or combination with oxygen and later to interpret such reactions in the light of valence changes. It is simpler to interpret the idea of valence changes as a transfer of electrons in the first reactions of direct union, which are studied in the course. The atoms of elementary substances are electrically neutral and exhibit zero valence. When magnesium burns in oxygen, the essential change is the loss of two electrons by each magnesium atom and the gain of two electrons by each oxygen atom. In the product magnesium exhibits a positive valence of two and oxygen a negative valence of two. When approached from this point of view, all reactions of direct union are the same kind of reaction. Whether the reaction involves union with oxygen or with some other electronegative element, such as chlorine, sulfur, etc., a transfer of electrons occurs.

A second type of reaction, which is included in the more general definition of oxidation, involves "the removal of hydrogen or its equivalent." When hydrogen sulfide is oxidized in the presence of a limited supply of air, the resulting products are water and sulfur. Other reactions of this type are the oxidation of hydrogen iodide by oxygen and of hydrogen sulfide by chlorine, etc. If these reactions are examined from the valence standpoint, we see that there is no change so far as the hydrogen is concerned. The essential change is the loss of electrons by sulfur and iodine, to oxygen in the first two instances and by sulfur to chlorine in the third. Oxidation of this type is not the removal of hydrogen, but the removal of electrons from the atom which was in a negative valence condition, bringing it up to the atomic, electrically neutral condition.

Oxidation is also often defined as "an increase in positive valence or a decrease in negative valence." These valence changes are also caused by the removal of electrons. A few examples which may be mentioned to

illustrate reactions of this type are the oxidation of ferrous chloride by chlorine, of phosphorus trichloride by chlorine, and of cuprous oxide by oxygen. The positive valences of iron, phosphorus, and copper increase because these atoms give up electrons to chlorine and oxygen, respectively.

Combination with oxygen and other non-metals, removal of hydrogen and metals, increase in positive valence, decrease in negative valence, all involve a common phenomenon, the loss of electrons by the atoms of the elements which undergo these changes. Oxidation may be most simply defined as the loss of electrons by some atom in the substance which is oxidized. These electrons are taken up by some atom in the substance which does the oxidizing and it is reduced. Reduction always accompanies oxidation and means simply a gain of electrons by some atom in the substance which is reduced. Such reactions are, therefore, reactions of oxidation-reduction and to call them oxidation reactions is to describe them incompletely. An oxidizing agent is a substance which contains some element in a valence condition such that its atoms readily gain electrons; and reducing agents contain atoms which readily give up electrons.

Ionic Replacement an Oxidation-Reduction Phenomenon

This idea of the electronic changes which take place during reactions of oxidation-reduction is illustrated simply by the displacement of ions from solutions. Ions exist as such and are different from the atoms of the same substance by virtue of the electrical charges which they bear. These electrical charges are due to either a deficiency or an excess of electrons over the number which the neutral atoms contain. The displacement of a positive ion from solution involves merely supplying a sufficient number of electrons to restore the atom to the electrically neutral condition. When zinc displaces copper ions from solution electrons are furnished to the copper ions by the atoms of zinc. This leaves the zinc in the form of ions and converts the copper into atoms.

$$Zn^0 + Cu^{++} \longrightarrow Zn^{++} + Cu^0.$$

Zinc atoms are oxidized, due to the loss of electrons to the copper ions, which are thus reduced to copper atoms. Copper ions may be discharged also at the cathode of an electrolytic cell. In this case copper ions receive electrons from the cathode and are therefore reduced.

$$Cu^{++} + 2\ (-) \longrightarrow Cu^0.$$

Chlorine displaces iodide ions from solution. That is, iodide ions furnish electrons to chlorine atoms and thus reduce them.

$$Cl_2^0 + 2\,I^- \longrightarrow 2\,Cl^- + I_2^0.$$

Electrons may be removed from iodide ions, thus oxidizing them, by elec-

trolysis. At the anode of an electrolytic cell iodide ions lose electrons and become in turn iodine atoms and then iodine molecules.

$$2\ I^- - 2\ (-) \longrightarrow I_2^0.$$

The position of a metal in the electromotive series depends on its activity as a reducing agent; *i. e.*, the tendency for its atoms to give up electrons and thus form positive ions.

In acid solution hydrogen sulfide and ferric chloride enter into an oxidation-reduction reaction which results in the formation of sulfur and ferrous chloride. The essential change is the gain of one electron by each ferric ion and the loss of two electrons by each sulfide ion.

$$2\ Fe^{+++} + S^{--} \longrightarrow 2\ Fe^{++} + S^0.$$

The activity of oxidizing agents depends on the tendency for some atom in its molecules to gain electrons. The active non-metals such as the halogens are good oxidizing agents. The outer shell of such atoms requires only one electron to reach a stable configuration and they consequently show a great tendency to gain these additional electrons. Molecules which contain atoms of non-metals in a positive valence condition, readily receive electrons, because stable compounds can be formed when these elements are in a lower positive valence. The atoms which contain a number of electrons in an incomplete outer shell exhibit several stages of oxidation, for it does not follow that when they lose electrons, they shall lose all of their outer shell electrons in one reaction. In the case of chlorine, the several stages of oxidation are represented by the following valence conditions.

$$Cl^-(KCl),\ Cl^0(Cl_2),\ Cl^{1+}(KClO),\ Cl^{3+}(KClO_2),\ Cl^{5+}(KClO_3),\ Cl^{7+}(KClO_4).$$

Chlorine itself readily receives electrons and it also does so when it is in positive valence conditions. In hypochlorous acid, chlorine has a positive valence of one. Its atom is, therefore, further from having a stable configuration than was the case when it was elementary chlorine. Hence, its avidity for electrons has been increased and the hypochlorites are powerful oxidizing agents. Hypochlorous acid will oxidize hydrochloric acid and the two chlorine atoms which collectively possess 34 electrons return to the elementary condition with 17 electrons each.

Nitric acid is a good oxidizing agent because it contains nitrogen in a pentavalent positive condition, and nitrogen in this condition readily receives electrons. When nitric acid reacts with copper the main products, under ordinary conditions, are copper nitrate, water, and nitric oxide. Every one will recall at once the four steps involved in representing this reaction according to the nascent oxygen idea. From the electronic point of view, the significant facts are the valence changes exhibited by copper

and nitrogen, which are due to a transfer of electrons from the copper to the nitrogen. The method of attack, which has been found very useful in teaching oxidation-reduction, from the electron concept, involves the following considerations. First the skeleton equation is written. This is based on experimental observations.

$$Cu + HNO_3 \longrightarrow Cu(NO_3)_2 + NO + H_2O.$$

Next the electron change as it involves the oxidizing agent is considered. When this is set down in the following manner, only the one substance receives consideration at the moment.

$$HNO_3 \longrightarrow NO;\ N^{5+} \longrightarrow N^{2+};\ \text{Gain } 3(-).$$

The reducing agent is considered similarly.

$$Cu \longrightarrow Cu(NO_3)_2;\ Cu^0 \longrightarrow Cu^{2+};\ \text{Loss } 2(-).$$

Since an equal number of electrons are gained and lost in an oxidation-reduction reaction, the ratio, obtained from the least common multiple of the numbers 3 and 2, is $2HNO_3 \equiv 3\ Cu$. But it will be observed that the three copper ions formed in this way require 6 additional nitrate ions, so that the total number of molecules of nitric acid required is 8. The balanced equation is written by returning to the skeleton equation and filling in the proper numbers of molecules.

$$3Cu + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O.$$

Compensating Valence Changes

A type of reaction which is puzzling to the student is the matter of compensating changes in valence such as those involved in the simultaneous change of potassium hypochlorite into potassium chloride and potassium chlorate, of phosphorous acid to phosphine and phosphoric acid, of sodium sulfite to sodium sulfide and sodium sulfate, etc. Such reactions are represented simply by the electron method. In the case of the hypochlorite mentioned above, the observed products which are obtained when a solution of the hypochlorite is warmed are the chloride and the chlorate.

$$KClO \longrightarrow KCl + KClO_3$$

$$KClO \longrightarrow KCl;\ Cl^{1+} \longrightarrow Cl^{1-};\ \text{Gain } 2(-)$$

$$KClO \longrightarrow KClO_3;\ Cl^{1+} \longrightarrow Cl^{5+};\ \text{Loss } 4(-).$$

Hence, two molecules of potassium hypochlorite are reduced to the chloride while one is oxidized to the chlorate.

$$3KClO_3 \longrightarrow 2KCl + KClO_3$$

The reason for what appears to be a curious and unreasonable self-oxidation, rests in a consideration of the structure of the chlorine atom. More stable valence conditions for chlorine are 1 negative and 5 positive, because these valence changes approach completed outer shells of electrons.

Hence, given the proper conditions, compounds containing chlorine in intermediate stages of oxidation redistribute their electrons to their mutual benefit. Under other conditions the change goes further and the perchlorate is formed.

A somewhat more difficult case which will be used as the final example to illustrate the simplification in equation writing obtained by the use of the electron concept, is that of the reaction of potassium permanganate with ferrous sulfate in the presence of sulfuric acid. As all will recall, the "step-equation method" using "nascent" oxygen as the valence vehicle involves several partial equations, some of which bear no relation to the observed products of the reaction. When these substances react, the observed products are potassium, manganous, and ferric sulfates and water.

$$KMnO_4 + FeSO_4 + H_2SO_4 \longrightarrow K_2SO_4 + MnSO_4 + Fe_2(SO_4)_3 + H_2O.$$

These are the qualitative facts of the experiment. The reaction is interpreted as consisting essentially of a transfer of electrons from bivalent iron to heptavalent manganese. The oxidation-reduction ratio in terms of electrons is derived by the method used above.

$$KMnO_4 \longrightarrow MnSO_4;\ Mn^{7+} \longrightarrow Mn^{2+};\ \text{Gain } 5(-)$$

$$2FeSO_4 \longrightarrow Fe_2(SO_4)_3;\ 2Fe^{2+} \longrightarrow 2Fe^{3+};\ \text{Loss } 2(-).$$

The least common multiple of the numbers 5 and 2 is 10, therefore, 2 molecules of potassium permanganate oxidize 5×2 molecules of ferrous sulfate. We may now return to the skeleton equation and complete the balancing in the usual manner. $2KMnO_4$ yield K_2SO_4 and $2MnSO_4$. $10FeSO_4$ yield $5Fe_2(SO_4)_3$. On the right of the equation 18 sulfate ions are represented, while on the left there are only 10 in 10 molecules of ferrous sulfate. Hence, 8 molecular proportions of sulfuric acid enter into the reaction and 8 molecular proportions of water are formed. The completed equation is:

$$2KMnO_4 + 10FeSO_4 + 8H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 8H_2O.$$

Advantages of the Electron Concept

Time does not permit the discussion of a more extended series of reactions to illustrate the application of this method. In order fairly to evaluate the possibilities of the method, one should recall that the development from the direct union type of equation first studied to that last discussed is very gradual and a large number of examples of each type of reaction are worked out. The customary order of introducing the various descriptive topics furnishes a series of reactions of gradually increasing difficulty so that by the time the student arrives at the complicated cases he is thoroughly familiar with the method. The conditions of the reaction and the generalizations based on a study of the Periodic System in the light of atomic

structure furnish valuable aid to the student in making this concept a useful tool.

The electron concept makes use of the modern idea of atomic structure in placing in a common category all reactions which involve valence changes whether they be reactions of direct union, reactions of displacement, electrolysis, or oxidation-reduction, involving compound substances. It is a simple and direct method of attack. It places emphasis on actual observations from the experiment and reasoning based on these observations instead of attempts to "dope out" the results which should be obtained. It avoids the confusion of committing to memory a "key" reaction for each of the oxidizing agents studied and each condition of reaction. It avoids the assumption of the addition or removal of positive charges, which would mean a change in the nucleus of the atom and therefore a transmutation of the element. The vehicle for representing the valence changes is the electron, the existence of which within the atom is definitely known. It is believed that this method represents the fundamental changes which actually occur during chemical reactions involving valence changes, and is also an easier method for deriving equations than the methods which work through the assumption of "nascent" substances.

Perkin Medal. Hugh K. Moore, technical director of the Brown Company, Berlin, New Hampshire, was on Janurary 16 awarded the Perkin Medal for his chemical engineering achievements, one of which was the development of the Allen-Moore cell for the electrolysis of brine.—*The Technology Review*

Committee Considers 75 Chemical Court Entries. Between seventy-five and eighty applications for the Court of Chemical Achievement to be held in conjunction with the Tenth Exposition of Chemical Industries at the Grand Central Palace, New York, during the week September 28th to October 3rd, have been received and most of them have been submitted to the Approval Committee of the American Chemical Society. Preliminary consideration of some of the applications, which are for new chemical products, instruments, equipment, and new processes developed in the United States during the past few years, indicate that a few will probably not be accepted. The majority, however, are expected to secure admission, although the final decision one way or the other rests with the American Chemical Society Committee.

In connection with the present industrial boom in the South, the Southern Section of the Chemical Exposition bids fair to be one of the largest groups this year. A number of leading chemical allied companies, railroads, and power corporations will have exhibits. Among some of the leading firms in this group will be the Tennessee Copper & Chemical Corporation; the Federal Phosphorus Corporation; the Southern Talc Corporation; the Southern Minerals Corporation; the Southern Railway System; Seaboard Air Line; North Carolina Department of Conservation; Manufacturers' Record; and a number of prominent power companies.

Up to the present time, something over twenty-five American universities have filed entries of chemistry students for the course for students in commercial practice of chemical engineering to be held for the second time at the Chemical Exposition this year, under the direction of Prof. W. T. Read of Yale University. A number of colleges have indicated that they will give credit to students attending the one week's course at the Exposition, in their regular work in chemical engineering. The general lectures and examinations will be on the practical phases of actual chemical plant work with leading authorities in the technical world giving the lectures.

Reports from the Chemical Exposition management state that the entire first and second floors of the Grand Central Palace have been contracted for by exhibitors, while a goodly portion of the third floor is already taken. Of course, the Court of Chemical Achievement, which will be on the third floor, will take a large part of this space and will attract many visitors to this floor. Total exhibitors to date indicate that this year's Chemical Exposition will be one of the largest industrial expositions ever held in the United States.

OBJECTIVES IN TEACHING CHEMISTRY

H. R. SMITH, LAKE VIEW HIGH SCHOOL, CHICAGO, ILL.

The Chicago Association of Chemistry Teachers, meeting under the auspices of the Chicago Section of the American Chemical Society, after study and discussion of the subject, present the following stated objectives in the teaching of chemistry as the consensus of their judgment.

I. To bring about as soon as possible the pupil's appreciation of training in scientific method and chemical knowledge.

Without interest or appreciation on the part of the pupil the teacher labors in vain. With enthusiasm failure is impossible. There is no justification, particularly in first year chemistry, for different objectives for those pupils who will continue the study of chemistry in college as compared with those who will not continue the formal study of the subject. The study of chemistry can furnish values fully commensurate with the effort put forth by any pupil irrespective of the vocation chosen in life. The primary emphasis should be placed on training; the subject matter comes second. The effect should be broadly cultural and not technical. On a very limited list of fundamental principles the work should be intensive. Beyond this it should be as extensive as possible.

II. To teach pupils the understanding and use of the scientific method of solving problems.

The highest appeal of education to pupils is that of achievement. Esteem and appreciation of friends and neighbors bring a satisfying state of mind to all who have the ability to perform useful work in a skillful manner. The world also pays tribute with various forms of wealth. The achievements of many eminent persons will serve the human race for all time. There is no greater good yet apparent that any human being can bring about. Effieient service guided by the best ideals of the age will prevent the decline of any nation.

The scientific method has proved its worth. All about us we can see the wonders wrought by the problem-solving power of the scientific method.

> "One of the only two articles that remain in my creed of life is that the future of our civilization depends on the widening spread and the deepening hold of the scientific habit of mind; and that the problem of problems in our education is therefore how to discover and how to mature and make effective this scientific habit..... It represents the only method of thinking that has proved truthful in any subject. That is what we mean when we call it scientific."—Professor John Dewey.

Professor L. H. Bailey has summed up the scientific method in his injunction: "Find the facts and know the truth." It may be definitely outlined in four consecutive stages.

1. Collection and study of the facts connected with a problem. (Data

already known may be found in libraries. Further data may be obtained only by suitable experiment.)

2. Formulation of hypotheses regarding the possibilities to be learned. (Inductive reasoning.)

3. Prediction of new data from the facts already known. (Deductive reasoning.)

4. Final testing of predictions by experiment to establish the truth.

III. The correlation of facts to build a unit of knowledge. (*A principle or law.*)

Details must be built into larger units of fact if the pupil is to comprehend the significance of the knowledge. The human mind refuses to carry a great mass of unrelated detail, but it can command great storehouses of knowledge properly synthesized into principles. Only when this process has been completed, can a single fact have significance. The part will have a meaning for him who knows the whole. He will understand the "various language" of daily events which speak to him not only through visible but invisible forms.

It is not sufficient to learn a law by repeating the statements of others. When information is obtained as stated in objective III it is still only information. It becomes knowledge when it is built into a general rule by the student. Nothing less will give him sufficient comprehension to make it useful as given in objective IV.

IV. Application of principles and laws to new situations in the solving of daily problems. (*Vocational and leisure time education.*)

When the pupil comprehends a principle in its entirety, he has a tool for solving problems. Just as a carpenter selects a tool for a given task so the student should be able to bring principles to bear on the problems of life. Drudgery is banished by intelligence and work becomes the expression of mankind in the service of the world. "This is my blessing, not my doom."

V. Coöperation in community groups to promote human welfare.

All science study is the attempt of human beings to comprehend the universe. It is so great that it is an impossible task for one person. By concentration on some small part of it one man can learn things of great value. When investigators coöperate in their several lines of study, then progress is possible along the whole front of science. In many ways the members of a community must coöperate to obtain desired ends. In matters of public health and safety negligent individuals are compelled to obey the will of the majority for the sake of the common good of all.

When the fate of the nation was in the balance during the World War, scientists from every line were gathered to one laboratory at Washington so that measures of defence might be evolved in the shortest possible time. The results proved the wisdom of the plan and point the efficient way for times of peace as well as war.

VI. Development of moral law and religious attitude in daily life.

Education that does not inculcate respect for the rights of others is negative education. There is general recognition of too much neglect of this objective in modern life. The boy and girl scout organizations have furnished splendid examples of effective religious training. Their effectiveness lies in the fact that pupils put into practice the principles taught according to statements of objective IV.

The honest student of science cannot be irreligious or atheistic for

"It is a sublime conception of God which is furnished by science, and one wholly consonant with the highest ideals of religion, when it represents Him as revealing Himself through countless ages in the development of the earth as an abode for man and in the age-long inbreathing of life into its constituent matter, culminating in man with his spiritual nature and all his God-like powers."—Joint Statement upon the Relations of Religion and Science by Forty Eminent Scientists, Religious Leaders, and Men of Affairs.

"I am not a subscriber to any religious creed, but I know from my study of science that there is a Creator of the universe."—Dr. Karl Guthe.

The New Rapid-Hardening Cement. A critical report has been made by Dr. Oscar Faber, consulting engineer to H. M. Office of Works, and one of the leading British authorities on cement, upon the recently-discovered rapid-hardening British Portland cement "Ferrocrete," a material by means of which many English local authorities are already shortening the period of work upon house building, road making and repair, etc., by many days.

Tests made under Dr. Faber's supervision at the City and Guilds Engineering College, South Kensington, revealed that concrete cubes made of the new cement have crushing strengths $3^1/_2$ times as great as ordinary cement at 4 days, $3^1/_4$ times as great at four weeks, and $2^1/_2$ times as great at three months. Reinforced concrete beams made with the new cement will stand a breaking load approximately 3 times as heavy at 4 days, twice as heavy at 4 weeks, and $1^1/_2$ times as heavy at 3 months as beams made with ordinary cement. There is indication, he adds, that these last-mentioned ratios (in each case) are maintained at greater ages.

Copies of the report are available free of charge from the British Portland Cement Association, 20 Dartmouth Street, London, S. W. 1.—*Chemical News.*

Colloids Occupy Stage at Minnesota. J. J. WILLAMAN AND L. H. REYERSON, University of Minnesota. For the third time in as many years a group of scientists convened from all parts of this country and from Europe to devote their undivided attention for a few days to the colloidal state of matter, when the third annual Colloid Symposium, under the auspices of the Colloid Committee of the National Research Council, met at the University of Minnesota on June 17, 18, and 19.

Although no new concepts of importance were presented, practically every phase of theoretical and applied colloid chemistry was touched upon, including soils, catalysts, paint pigments, protoplasm, soaps, emulsions, orientation of molecules, electrokinetic potentials, photographic sensitizing substances, bacterial toxins, blood coagulation, aluminum flocs in water purification, plasticity of rubber, and motion pictures of colloids as seen in the ultramicroscope.

To the teacher of chemistry, the fact that molecules tend to orient themselves on the surfaces and interfaces of liquids is of considerable interest. For instance, in any alcohol the OH groups tend to stay in the water and the alkyl groups to project themselves out of the water. In some other solvents the reverse is true. The same holds true for the carboxyl group in fatty acids. These phenomena aid in explaining the change in solubility as we proceed along an homologous series. Another fact of interest to teachers is that when hydrogen is adsorbed in a silica gel, it acts as a metal surface, taking its proper position in the electrochemical series. For example, it will not displace nickel but it will silver and palladium.

It was announced that when a virulent culture of diphtheria organisms is treated with a soap, as sodium ricinoleate, the soap is adsorbed on the surface of the organisms. This reduces their surface tension, with the result that when they are injected into a guinea pig, they no longer show toxic symptoms. They still, however, have the power of inducing the formation of antibodies.

The movies showing the Brownian movement of colloidal particles under the ultramicroscope, and their coagulation under certain conditions, demonstrated a new means of instruction in this field of chemistry.

CHEMISTRY AND SCIENCE IN PREHISTORIC AMERICA

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When thinking of the efforts of primitive man along the lines of chemistry and science, it is usual to consider only the European and his early struggles to rise above savagery. In this article, it is the purpose of the writer to call the reader's attention to the fact that the American Indian, while still living in the Stone Age, had a wide knowledge of natural laws and took advantage of many reactions of scientific interest. The American Indian was not the ignorant savage we are led to believe, but had methods of working, which could only be the result of thought and experimentation. Barbarian he may be called, but compared with the natives of Africa or the Australian Bushman, he was no savage and his works and culture before the coming of the white man were far superior, more characteristic and much more interesting than those of many of his descendants today who live on reservations and whose main occupations are the manufacture of bead-work and blankets, neither of which are truly Indian in character.

Chemical Operations
Mechanics
Practical Geology
Craftsmanship
Medicine
Astronomy
Dyeing
Agriculture
The Indian a Worker

Chemical Operations

The American Indian knew nothing of chemistry or geology, as we understand those terms, yet his quick and active mind was ever ready to take advantage of any chemical combination or geological condition which his surroundings or activities brought to his attention. We know he had a knowledge of the cleansing value of caustic alkali, as we have evidence and records to prove that in chipping flint to make arrow points, spears and knives, a piece of bone which had to be absolutely free from grease was used, and to obtain this the bone was scoured or sometimes buried in hot ashes moistened with water, the result, as every chemist knows, being the saponification of bone grease and potash, the same principle as that involved in the manufacture of soft soap today. This saponification of the grease from the bone chipping tool was a very important matter, as a fresh or greasy bone will slip, but a clean dry bone, with the proper pressure, produces results not attainable with any other material.

The art of tanning hides was well understood and by the use of simple barks and the brains of animals, the Indian made a leather which, in softness and durability, can hardly be equaled today, while the glue with which he fastened feathers to his arrow shaft was made from the scales of fish and equaled the common fish-glue with which we are all familiar. He

knew the water-proofing properties of pitch and used it on the seams of his birch-bark canoe.

In the manufacture of bowls and bottles he knew enough to temper clay with powdered mussel or other shells and produced a pottery which is durable today after being buried hundreds and perhaps thousands of years. Throughout the Mississippi Valley this pottery was frequently decorated with scrolls and markings of red, made by applying oxides of iron before burning. As to art in pottery, no one who has examined the effigy vases and bottles from graves in Missouri and adjacent states can deny that the prehistoric Indian had a culture of his own in pottery.

Mechanics

In mechanics he had not advanced far, yet he knew the value of the lever, applying it skillfully in shaping and flaking those large flint spades which are so numerous along the Mississippi River from St. Louis to the Gulf. He also knew and used the reciprocating drill, which he made by giving a bow-string a turn around a hollow reed and moving the bow backward and forward, using water and sand as an abrasive material at the point of the drill. In this manner he made holes of any length through slate and sandstone. In some cases his drill points were of sharpened flint and his reamers were simply small tapering points of flint with a broad base for hand use. The reciprocating bow-string drill was also used for making fire.

Geology

As a practical geologist he reached a very high point, his knowledge of rocks and their cleavage being exceptionally good. Although we hear solely of his flint artifacts, as a matter of fact, flint was used only for arrow and spear points and knives. The writer has examined hundreds of axes, and, as yet, has never found one made of flint. An axe or tomahawk made of that material, while hard, would chip or flake at every stroke and would soon be rendered useless. Accordingly, he searched the fields and streams for water-worn pebbles of diorite, basalt or other close-grained sandstones, which were pecked and ground into shape, giving a tool whose edge would not chip and dull as would one made from the more flakable flint. In the Middle West axes were frequently made of hard hematite and some retain their polish and cutting edge to this day. It took considerable skill to grind these hematites into shape, as they quickly wear out the hardest file; yet some are symmetrically made and almost as serviceable as the steel axe of today. There are a number of hematite axes in the National Museum at Washington, D. C.

Craftsmanship

When it came to making ornaments, he again chose suitable material, generally slate, which could be easily worked up into gorgets, pendants and

banner stones, and afterward polished with mud. For his pipes he selected the softer sandstones, usually the red variety known as catlinite, although in the Iroquois country and some parts of the South, pipes were made of baked clay. To this day we have made no improvement on the Indian's pipe or his methods of using tobacco. Some of the carved stone pipes of the Middle West representing animals, birds and man himself are really remarkable.

The manufacture of a simple arrow-point demanded much knowledge and some research. First the fields and hills were "prospected" for a suitable quarry of workable stone. Next the top-soil was removed and the jasper or quartz or other material heated by building a huge fire over it. Then cold water was thrown over the hot stone, which, being of a siliceous nature, cracked into many small pieces. These pieces were roughly shaped at the quarry by hammering, and then transported to the village. Here they were buried to keep them fresh, as jasper or flint is more workable if fresh from the ground and not dried out. But the arrow-point was still incomplete, the finishing touches demanded not only skill and practice, but also a complete knowledge of the cleavage of stone, so that pressure could be applied to make a chip or flake of any size fly off in the direction desired and this done by holding the stone in one hand and applying the bone instrument with the other. It is only after we have tried to do this on such stones as quartz or argillite that we fully appreciate the amazing skill of our copper-hued friends. In fact, the chipping or flaking of stone can easily be considered a science in itself. Yet along the Atlantic Coast quartz was much used for arrows, due perhaps to the scarcity of good workable flint, and in the extreme West obsidian was used with equal or even better results.

An important industry along the Eastern coast was the manufacture of wampum, which passed as money. This craft called for much mechanical skill and considerable practice. Wampum was made from the shells of the large hard clam and both the purple and white shells were used. The purple beads were usually slightly longer than the white beads and had double their value. It was tedious work grinding these tiny beads to shape, but real skill was needed to drill them and here, again, the mechanical drill was brought into play.

Medicine

Regarding the practice of medicine, so much has been written of the incantations and "bundle" of the Medicine Man that most people believe this to have been the only method employed, but the red doctor also had a good knowledge of herbs. The Indians of the Eastern States were familiar with the curative powers of wintergreen (methyl salicylate), using the leaves as a poultice for sprains and rheumatic troubles. The early

settlers learned of this wonderful herb from their redskin friends and studied its properties. From this study we have developed all the salicylates, such as salol (phenyl salicylate), aspirin (acetyl salicylate), and many others. The Indians of Peru chewed the dried leaves of the coca plant mixed with limestone (carbonate of lime), and swallowed the juice, after which the acids of the stomach extracted the cocaine which relieves pain and fatigue. We have refined the process by treating the leaves with carbonate of soda and extracting with dilute acids, but the resultant alleviation of pain is identical. Calisaya and quinine, both derivatives of cinchona bark, are Indian discoveries, as are jalap from Mexico and many others. Sweating was also much used, the patient being wrapped in blankets and placed in a small tent surrounded by red-hot stones over which water was poured to make a very efficacious steam bath.

The antics and tricks of the Medicine Man which we all ridiculed for years were simply the art of "suggestion" carried to a very high point. The Indian doctor who made all sorts of noises to drive away the "evil spirit of pain" or who pretended to extract a live "sickness" bug (which he usually concealed in his mouth) was not a fraud, if by his works he convinced the patient that he was surely on the road to recovery. Our greatest physicians now recognize the virtues of suggestion and use it wherever possible and we also have today a religious sect based on the same principle.

Astronomy

In astronomy the Indian had not reached the point of calculating distances, but he knew the movements of the principal planets and had names for them. Even the Indian boy could find his way at night through the dense forests by the aid of the stars alone and it is not amiss to state that the average prehistoric American knew more about the movements of the heavenly bodies than the average white man of today. If we cross into Mexico we find that, years before it had been correctly computed by Europeans, the Aztecs had calculated exactly the solar year, using instruments of the crudest type.

Dyeing

He had a good knowledge of the common pigments, using hematite for brown and red, malachite for green, and ochre for yellow, while for dyes and stains he used the juices of berries, nuts and barks from various trees. Some of the dyes were very fast, particularly when a metallic mordant, such as iron salts (from fruit juices and oxides of iron) was used in conjunction with vegetable extracts.

Agriculture

As a farmer, he raised corn (the Indian name for which is maize), potatoes, squashes, beans of various sorts, and numerous other vegetables.

Many years before Dr. Liebig made his great discovery regarding fertilizers, the American Indian of the Eastern Coast fertilized his corn fields by throwing over them the dead menhaden (fish), which were frequently found along the beach in great quantities, and in this manner supplied the soil with necessary phosphates. These menhaden were driven on the beach by the bluefish and the phenomenon of millions of dead fish along the surf line was more common years ago, before the menhaden boats started putting out their great nets. However, we still gather menhaden for fertilizer and oil.

In this article the writer has confined himself almost entirely to the ancient peoples of the United States, but if we are to mention architecture we must go to Mexico and view with amazement the ruins of temples and pyramids at such places as Uxmal, Palenque and Teotihuccan. In our own country we have the cliff houses and the mounds.

The Indian food and cooking still linger with us and every day we hear of potatoes, succotash, maize, hominy and tapioca—all Indian names of Indian foods which he planted and raised himself. How few of us remember that turkey, the Christmas bird, was eaten by the red man centuries before America was discovered!

The Indian a Worker

Frequently we hear that the Indian was lazy, but even a brief study of the early records will contradict such charges. Besides the work already mentioned, there were baskets to be made from rushes and cane, textiles from the shredded inner bark of trees, garments and moccasins from skins and feathers, fishing, hunting and ceremonial and other dances held at regular intervals. Tepees and bark huts were constructed and again taken apart and moved to different camping grounds as the game or fish were followed in their migrations. Games he had in abundance, including dice, la crosse, foot and snow-shoe races, ball games of various sorts, quoits made of stones and many others. Then there were weddings, birth and death ceremonies and an occasional war with neighboring tribes as diversions. When we consider all this together with the fact that he had only the crudest implements for planting and harvesting we certainly must admit he was, in his primitive state, a very busy individual.

It is to be regretted that the early discoverers and adventurers did not have with them investigators who could have made exact records and conceded to the primitive people of our country the place in ethnology they deserved, namely, that of the Stone Age Men of North America.

EDUCATING THE PUBLIC IN THE USE OF THE METRIC SYSTEM

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Wide Adoption of the Metric System
Educating the Public
Confusion Arising from the Old Systems
Teaching the Metric System
Ease of Metric Calculation
Interrelation of Metric Quantities
Ease of Transition to Metric System
Education Will Overcome Opposition

Wide Adoption of the Metric System

The world is mostly metric. Only Great Britain and the United States have failed officially to recognize the advantages of a simple, sensible, yet universal system of measurement. The rapid advance of metric usage is strikingly exhibited in a chart prepared by the Metric Association—Figure 1. The two remaining non-metric countries do not have even the advantage of a system in common. The same *names* for units of measurement are used in the British Empire and in the United States; but unfortunately the *values* of many of these units are quite different—a fact which leads to endless confusion. This awkward situation is indicated in Table I.

TABLE I—MANY UNITS OF THE SAME NAME HAVE DIFFERENT VALUES

1 Liter	
= 1.0567 liquid quarts (U. S.)	
= 0.9081 dry quart	
= 0.8798 Imperial quart (Brit.)	
Imperial quart 20% > liquid quart	
Dry quart $16^1/_3$% > liquid quart	
Imperial gallon	277 Cu. in.
Standard gallon (U. S.)	231 Cu. in.
British gallon = 1.2 U. S. gallons	
Hundredweight (U. S.)	100 lbs.
Hundredweight (Brit.)	112 lbs.

Here in the United States we have the anomalous existence of a set of complicated weights and measures officially defined by the Bureau of Standards in terms of the international metric standards. The use of the metric system in this country has been constantly increasing as its merits in the economy of time, materials and patience have become more appreciated. In the opinion of those familiar with the situation, it is only a matter of a short time until metric standards will be legally established for general use in this country.

Educating the Public

Now that the universal adoption of the metric system seems to us as

inevitable as it is desirable, should not an effort be made to familiarize the public with its use? As Professor Bingham pointed out in a recent article,[1] there is a surprising lack of information on the metric system and much misapprehension concerning its adoption. The educational system of the country will be called upon to help make this transition as easy and satisfactory as we have always claimed it would be. The public must be thoroughly convinced that the metric system is preferable in every respect, or there will be as much difficulty encountered in establishing metric usage as there has been in enforcing the Volstead Law. For the former purpose a few suggestions are offered in this paper.

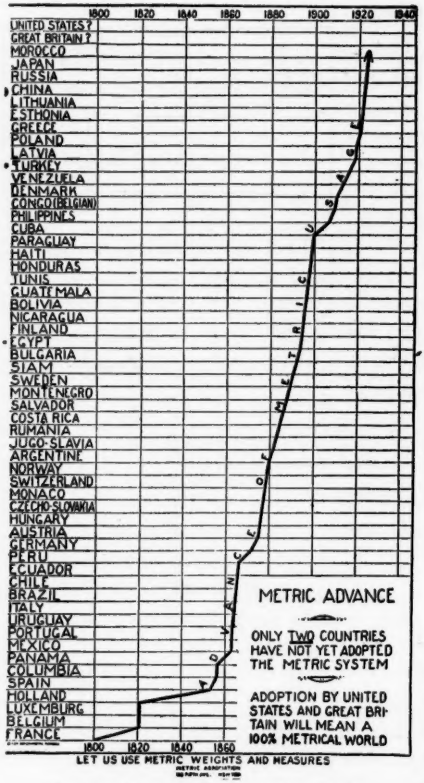

FIG. 1.—The world is mostly metric.

Confusion Arising from the Old Systems

First, let us indicate the confusion in our present units of measurement and the need for standardization. Table II suggests the complexity of our every-day quantities. Most people are ignorant of the existence of two kinds of quarts and of the fact that the quart for measuring solids is greater than the liquid quart. If the grocer uses a liquid quart measure for solids, the customer is cheated to the extent of $16\frac{1}{3}$ per cent.

A glance at the "Tables of Weights and Measures" in a school arithmetic will recall to most of us painful hours spent in trying to memorize the irregular relationships of the various and manifold units. It is with nothing less than sheer cruelty that we force upon school children the memorizing of these absurd tables of measurement which few of us can (or would wish to) remember for long. In abolishing this torture, the saving to the educational system can be calculated in millions of dollars,

[1] THIS JOURNAL, **2**, 62 (1925).

TABLE II—MORE CONFUSION! THE VALUE OF THE UNIT DEPENDS UPON THE SUBSTANCE TO BE MEASURED

1 lb. Butter—16 Oz.—7000 Grains—454 Grams 1 Lb. Gold—12 Oz.—5760 Grains—373 Grams
1 Qt. Beans—$^1/_8$ Peck—67.2 Cubic inches 1 Qt. Molasses—$^1/_4$ Gal.—57.75 Cubic inches
130 Kinds of Bushels now in use in U. S. 391 Different Units have been called "Pound." 282 Different Units have been called "Foot."

yet the most important economy is that of human time and effort. The simplicity of the metric system is shown in Table III. For all practical purposes one needs to learn only the three fundamental units and the six prefixes indicating decimal relations.

TABLE III—THE METRIC SYSTEM CONDENSED

Kilo	1000
Hecto	100
Deka	10
Meter Liter Gram	
Deci	.1
Centi	.01
Milli	.001

Teaching the Metric System

Evidently a transfer of educational material must occur. The Metric System of weights and measures should be taken out of Chemistry and Physics and placed in Elementary Arithmetic. This will lighten the load on the teachers of those sciences, and will at the same time bring us students with a better sense of the reality of grams and liters in the problems we set them. Many of the tables of the so-called English System of weights and measures, now taught in Arithmetic should be relegated to Ancient History—if they need be mentioned at all. Pharmacy and Medicine will do well to abandon Apothecaries' Measures in favor of metric standards, since students in those professions are familiar with the latter from their training in Chemistry. It seems extremely unfortunate that we should dissipate our educational energy by teaching two different systems of

measurement. Arithmetic teaches the old units; the fundamental sciences in college and high school introduce and employ metric units; Engineering, Medicine and other professions, whose members have had thorough experience with metric units, return to the old units in practice or complicate matters further by using an entirely different set of tables. The newer branches of engineering dealing with electrical and kindred phenomena employ metric units. The medical profession does likewise to some extent, and the American Medical Association with 82,000 members is on record as favoring the exclusive use of the metric system. From the standpoint of educational economy alone, we should agree to use some one system.

Ease of Metric Calculation

In addition to the fact that the metric system will be used throughout the civilized world, the attention of the public should be called to its two intrinsic advantages. First, it is a *decimal* system. Undoubtedly man first learned to count on his fingers, of which he has ten, so a decimal system of enumeration is the natural outgrowth of the cave-man's adding machine. Furthermore the Arabic system of numbers, one of the greatest inventions of all time, has ten ciphers, so decimalization is the normal method of extension for all calculations. The decimal system lends itself to slide rules and calculating machines and has a direct relation to our decimal monetary system. Mental and written calculations will be facilitated, and persons of limited education will be enabled to determine for themselves the price of what they buy and sell.

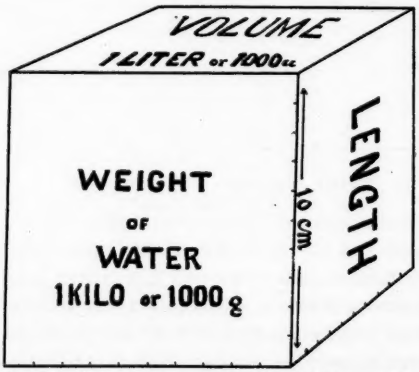

FIG. 2.—The fundamental units of the metric system are related.

Interrelation of Metric Quantities

Secondly, in the metric system the units of length, volume, and weight are *interrelated* as shown in Figure 2. A volume of water, measured in cubic centimeters may be used in place of a set of small weights. It is a simple matter to determine with a meter-stick the capacity of any container in liters by multiplying together its dimensions expressed in centimeters and moving the decimal point three places to the left. Compare the relative amounts of mathematics involved in calculating the volume of the same box in quarts and in liters:

$8^3/_{16}$ in. × $5^1/_4$ in. × $12^1/_8$ in. ÷ $57^3/_4$ = ? Quarts
20.8 cm. × 13.34 cm. × 30.8 cm. ÷ 1000 = ? Liters

How many workmen, or even college freshmen, could cope with the common fractions in the first calculation? The specific gravity of materials is an important and useful property in common usage. In the metric system specific gravity is simply the weight in grams of a cubic centimeter of the material—the weight of any specimen divided by its volume. No such relation exists in the inch-pound-quart system of measurement. In contrast to the preceding figure, the entire absence of any relation among our present units is illustrated in Figure 3.

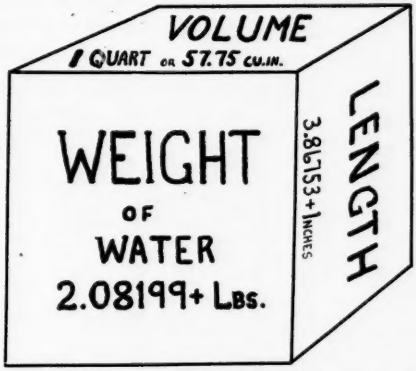

FIG. 3.—There is no relation among the units in the inch-pound-quart system.

The actual values of the metric units can be most effectively taught by comparing them with the units already familiar. Figure 4 presents relationships which are sufficiently accurate for most purposes. It also points out the odd method of subdivision of our common units as compared with the decimalization of metric units. In Table IV the metric values of some other common quantities are set forth. It will be a practical convenience to be able to use silver coins as small weights.

TABLE IV—THE METRIC SYSTEM MAY BEST BE TAUGHT IN TERMS OF QUANTITIES ALREADY FAMILIAR

FAMILIAR METRICS
1 "Carat" weighs $^1/_5$ g. or 200 mg. 1 "Nickel" weighs 5 grams 1 "Dime" is 1 mm. thick (or thin) and weighs 2.5 grams
(Other silver coins accordingly) A postage stamp is 2 × 2.5 cm. and weighs about 50 mg.
1 drop of water is about $^1/_{20}$ cc. and weighs about 50 mg. 1 Teaspoonful is about 4 cc. 1 Fluid ounce is about 30 cc. 1 Cupful is 8 fluid ounces

Ease of Transition to the Metric System

The establishment of standards of measurement is one of the powers of Congress. The Britten-Ladd Bill, which will be presented at the next session, provides for a gradual transition to metric standards, to be completed by 1933. It is less drastic in its proposed operation than previous bills for this purpose, and is favored by the national organizations of labor, the industries, and the professions. In our competition for foreign trade the use of the metric system has become a necessity. This is especially true with respect to our South American customers, as their credit is good anywhere. The prosperity of the industries of the United States depends

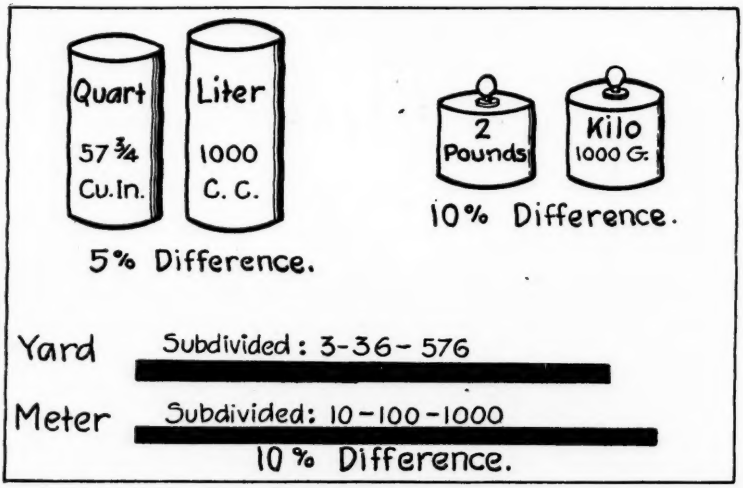

FIG. 4.—The approximate differences between the old units and the metric units is easy to remember.

upon this trade; so commercial necessity will probably be the most impressive practical argument for the proposed legislation.

Metric standards have been legal in this country since 1866, and a considerable proportion of the population is already familiar with the metric system. This acquaintance has been gained from science courses in schools, from military service, from an interest in popular science—particularly radio.

Education Will Overcome Opposition

The opposition to the metric system is neither general nor well founded. It is due to misconceptions and to an idea of tradition. Many of its opponents will become supporters when better informed, and the tradition

becomes inverted when it is realized that the metric system is English and not French in origin, while the so-called English system is a German invention which has been discarded by its fatherland. James Watt, the English scientist and engineer, originated and first published the decimal system of measurement, so Great Britain and the United States should have been the first, rather than the last, to adopt it.

Report Results of Research on Odorous Constituents of Cotton Plant. Dr. F. B. Power, chemist in charge of the phytochemical laboratory of the Bureau of Chemistry, presented to the National Academy of Sciences at a recent meeting in Washington, D. C., the results of research by himself and V. K. Chesnut on the odorous constituents of the cotton plant.

"The investigation was undertaken," says the report, "at the request of Dr. L. O. Howard, chief of the Bureau of Entomology, and the primary purpose was to ascertain the chemical character of the odorous constituents of the cotton plant. Inasmuch as this plant possesses a specific attraction for the boll weevil, it has been presumed that this was due to the emanation of some odorous substance which could be perceived by the insects at a considerable distance. It has furthermore been considered that if any odorous substance could be identified, which by chemotropic tests would be found attractive for the insects, it might be possible to produce it in sufficient quantitities to permit of its use as bait."

Doctor Power reported that the concentrated distillate from the plant, which represented all its odorous and volatile constituents, was the product employed for their separation and identification. It was found to contain a large number of individual substances, including ammonia and trimethylamine. Both of these basic substances were likewise found in the dew collected from the leaves, and it has been shown that they are emanations from the living plant.

Although trimethylamine has been found by field tests to possess some attraction for the boll weevil, much more extended experiments in this direction have still to be undertaken by the entomologists.

Doctor Power stated that, "If the results of the present investigation should ultimately prove to be of practical utility in controlling the ravages of the boll weevil, they would seem to point the way to a new and larger field of research, for it is conceivable that the attraction which various other plants possess for certain insects may be due to some odorous substance exhaled by them."—*Official Record of the U. S. Dept. of Agr.*

New Cure for Pellagra Announced by Government. The United States Public Health Service has announced results of experiments which prove that severe cases of human pellagra can be either prevented or cured by means of dried yeast. Surgeons Joseph Goldberger, G. A. Wheeler, and W. F. Tanner, after the successful treatment of 25 out of 26 patients, have just united in a report which reveals that they were led to this discovery by following another disease in dogs.

Black tongue, a bacterial disease with somewhat similar effects on the skin as are produced in severe cases of pellagra, also a bacterial infection, was produced experimentally in dogs. Then the dried yeast was given. The cures were so satisfactory in the cases of the dog disease that the Public Health Service surgeons tried the yeast treatment on pellagra patients. As early as the second or third day after the treatment beneficial effects were noted.

It is only in severe cases of pellagra that such dried yeast treatment is necessary as in milder cases careful feeding is sufficient, the surgeons declare. Brewer's yeast has been used so far, but the experimenters believe that bakers' yeast will work as well.—*Science Service.*

Predicts Use of Smokes to Build and Paint Houses. Fine dust from chimneys will, undoubtedly, in the near future, find some commercial use in the industries either as filler for paint, fertilizer, or other products, or as a base for some building material, according to Prof. A. G. Christie of Johns Hopkins University.

Much work is now being done to develop methods of catching the fine particles which fly up the chimney with the flue gases, he pointed out.

"It should be a public duty," he says, "to reduce as far as possible the discharge of dust and smoke from chimneys of stoker plants and of those using pulverized coal. Such dust floating in the air lessens the amount of sunlight reaching the surrounding earth, increases fog conditions, increases the cost of keeping cities clean, increases disease, and lessens the health and vitality of those who breathe the air it contaminates."—*Science Service.*

THE NEW ASSISTANT

A METRIC PLAY, BY ALTON L. HALL AND THE GENERAL SCIENCE CLASS OF BISHOP, CALIF.

With the exception of CREAKY, no costumes are necessary beyond a band of muslin fifteen centimeters wide for each nation. The band bears the name of the country represented, and is worn right shoulder to left hip. These bands, ready for use, may be borrowed from the author. A minimum of nine actors is required. One of them should be a girl. As many as fifty-nine could be used. See list of nations using the metric system in THIS JOURNAL for Jan., **1925,** page 64. The time is supposed to be 125 years ago, but changes to the present during the play. The curtain rises showing FRANCE seated at a desk or table R. center.

France—"Creaky is too slow; yesterday I wanted to know the cost of one pencil when the price per gross was given, and it took him so long to find it that I went away and left him figuring. I hear that there is a young lady, recently arrived, who can tell the answers instantly, without writing a figure."

Miss Metric (entering from R.)—"Good-morning, sir; would you like to hire an assistant for your office?"

France—"Meaning you?"

Miss Metric—"Yes, sir."

France—"What can you do?"

Miss Metric—"Weigh and measure, and reduce and compute."

France—"I have an old servant who looks after my accounts; I doubt whether you could do the work."

Miss Metric—"You might give me a trial, sir."

France (shouts toward L.)—"O, Creaky! Come here a minute." (Creaky enters from L. He is bent, and leans on a yardstick.) "Creaky, this is Miss Metric, who is applying for your position. Show her how quickly you can do your work. This platform is, say, thirty-two feet ten inches long; how many inches would that be?"

Creaky—"Did you say, 'how many inches'?"

France—"Yes."

Creaky—(crosses behind Miss M. and goes down R. to a blackboard.) "Let me see....." (multiplies it out, naming the figures as he works), "394, sir."

France—"Well done, Creaky. Now, Miss Metric, it is your turn. This room is, say, thirty-two meters and ten centimeters long. How many centimeters would that be?"

Miss M. (confidently)—"Thirty-two hundred and ten, sir."

France (surprised)—"But you didn't figure it."

Miss Metric—"I didn't *need* to. I have the advantage of your servant in that where he had to multiply by twelve, I had only to multiply by one hundred, and I can do that in my head."

CREAKY wipes his forehead.

France—"Simple! Let's try another kind. Creaky, what *fraction of a mile* would your 32 feet 10 inches be?"

Creaky—"Fraction of a mile?"

France—"Yes."

Creaky—"Let me see.....A mile is 5280 feet. I'll have to change that to inches."

He figures it out on the blackboard, and finally announces the result.

France—"And now, Miss Metric, what fraction of a *kil*ometer would your 32 meters and ten centimeters be?"

Miss Metric—"Thirty-two thousandths, sir. The exact figures are 0.0321."

France—"Well, I'll be hanged. How did you *do* it?"

Miss Metric—"Here, again, I had the advantage over your servant. He had to divide by 5280 times 12; I had only to divide by 1000, and I can do that in my head; just move the decimal point three places to the left." (To the audience)—"I do all my measuring and weighing in the same way that you count your money." (Shows meter.) "In your money, ten mils make one cent; here, ten *mil*limeters make one *cent*imeter. You have ten cents making one dime; I have ten *cent*imeters make one decimeter. You have one hundred cents making one dollar; I have one hundred centimeters making one meter. The problem he gave me is as though someone should ask you how many cents there are in thirty-two dollars and ten cents. You could answer at once: thirty-two hundred and ten. Or what fraction of a thousand dollars thirty-two dollars is—it is 0.032. In changing from one denomination to another, I never have anything to multiply or divide by any number except 10, 100 or 1000, and I can do that in my head.

(Voice off stage L.)

"Creaky! Where's Creaky? Here he is."

FRANCE seizes CREAKY and marches him across stage to meet the nations.

France—"You may *have* your old servant; I have a better one."

Nations—"Who?"

France—"Miss Metric."

Several Nations—"Never heard of her."

Belgium—"*I* have; and since she is satisfactory to you, I'll hire her too."

Goes across stage to R., and is welcomed by Miss M. Several other nations follow. Curtain may drop here to show lapse of time. If the cast is small, all except England and U. S. and CREAKY cross at this time.

France—"Wouldn't it be fine if *all* the nations would let Creaky go?"

Belgium—"Think of the poor *school* children in England and the United States—millions of them—and the wasted years they spend in school learning tables, useless tables."

Germany—"And figuring long problems about them; all unnecessarily."

China—"And those *common* fractions, *improper* fractions and *vulgar* fractions!"

Japan—"What slavery!"

China—"They need enlightenment; they need missionaries."

France—"It makes me *angry* when I think of it. Uncle Sam, let me see one of your arithmetics."

Crosses to L., gets book—a large one—comes down stage and says to audience, showing book:

"No *wonder* his young men enter college so late in life. Miss Metric, let's see what would be *left* of this book if the unnecessary stuff were taken out."

Miss M. tears out stuck-together sections from Fractions, Denominate Numbers, Aliquot Parts, etc., each having a short problem marked for reading, such as "Express 2 gills and 1 pint as quarts; as gallons." The nations come up and receive these sections, read the problem distinctly to the audience, and wad up the paper and throw it at ENGLAND and the U. S. CREAKY gathers them up and smooths them out. Instead of problems, the following may be used: 144 sq. in. one sq. ft.; 1728 cu. in.; 231 cu. in.; 62.4 lbs. of water; 550 ft.-lbs. sec.; 36 in.; $16\frac{1}{2}$ ft.; $5\frac{1}{2}$ yd.; 9 sq. ft.; 27 cu. ft.; 16 oz.; 8 qts.; 4 pecks; 32 qts.; $31\frac{1}{2}$ gal.; fathoms, scruples, ounces Av. and Troy.

MISS METRIC crosses to L. and faces ENGLAND and U. S. appealingly.

Miss Metric—"For the sake of your *children*!"

ENGLAND and U. S. look at each other sheepishly. MISS M. waits an instant, then returns sadly and reluctantly.

Japan—"John Bull, why don't you come across? You look lonesome."

England—"I am a *manufacturing* nation, don't you know. Think of the machinery I would have to scrap if I adopted this bally system. My lathes, for instance, are made to cut threads in eighths and sixteenths of an inch."

Japan—"Yes, and by the addition of *one wheel* having 127 teeth they will cut any metric thread known."

England—"But I am conservative, don't you know. I can't take up with every new thing that comes along."

France—"How long do you need? It was 125 years ago that *I* made the change. Fifty-four other nations have ventured since then, and none have gone back."

England—"But Creaky is an old friend of mine. He was good enough for my grandfather and his grandfather, and he is good enough for me."

China—"I *worship my* ancestors; yet I adopted this system. If you had as much grit as your ancestors, you would adopt it too. Have you ever seen an auto? Have you heard of the radio yet?"

Argentine—"Uncle Sam, why don't *you* come across? There are many of us who would like to buy your machinery, but if we do, and anything goes wrong with it, we can't get it repaired, since our machine shops use only metric scales and sizes."

U. S. (haughtily)—"If you don't like them the way I make them, you will have to do without."

Argentine—"Not when we can get what we want elsewhere."

China—"Germany and Japan will supply us; won't you, Japan?"

Nations crowd around GERMANY and JAPAN, asking, "Will you supply me?" and shaking hands. U. S. and ENGLAND do some thinking.

Germany (to U. S. and Eng.)—"Stick to your old system; I will supply the world with what they wish."

U. S. (to Argentine)—"But instead of buying my sugar in 100-lb. sacks, I would have to buy 45 and a long decimal fraction *kilos* of sugar."

Argentine (bringing forward an empty sulfur sack)—"Not at all. You would buy your sugar as you buy your sulfur—in 110-lb. sacks holding 50 kilos."

U. S.—"But my chickens lay eggs by the dozen; what am I to do about that?"

Argentine—"You're mistaken, they lay them by ones. *You* are the one who lays them by the dozen, and you could just as easily lay them by tens, hundreds and thousands. And your boxes of canned goods could be packed in four rows of five in a row as easily as three rows of four in a row."

Miss Metric—"Your *people* are more progressive than you are, Uncle Sam. They are using the metric system in radio, in the Olympic games, in high schools and colleges, in scientific work, and to some extent in manufacturing. The Manufacturers' Association of San Francisco petitioned Congress to adopt this system, which is now in use by over ten times as many people as use all other systems combined. They realize that we are losing millions of foreign trade every year by not adopting it." (Creaky trembles; Miss M. goes nearer, appealing.) "For the sake of your foreign trade, Uncle Sam, and you too, John Bull!"

England—"Isn't she a beauty! I say, old chap, I'll adopt her if you will, and we'll make the world 100% metric." (Creaky collapses.)

Nations—"Hooray." (Embrace one another.) "Now, Uncle, it's up to you." (A hush.)

U. S.—"All right, John, I'll do it; that is, if I can get Congress to back me."
Nations—"Congress? Hooray! Hot dog!"

Great rejoicing; surge toward U. S., who motions them to stop, saying:

U. S.—"I forgot. You know the Senate....."
Nations—"Oh, the SENATE. Good-night!"

The Remington Honor Medal. The New York Branch of the American Pharmaceutical Association has awarded the Remington Honor Medal for this year to Dr. Henry M. Whelpley of St. Louis, Mo. The recipient of this prize stands out as one of the most renowned and ablest exponents of American Pharmacy.

In the address at the recipiency of the medal Dr. Whelpley said: "The mortal touch of Professor Remington has died, but his work and influence will pass on unto future generations through many pharmaceutical and chemical agencies.—*J. Am. Pharm. Assoc.*

Mount Wilson Experiments Not Fatal to Relativity. Experiments performed by Dr. Dayton C. Miller, of the Case School of Applied Science, Cleveland, at the Mount Wilson Observatory, California, do not disprove the theory of relativity, as many astronomers have claimed, says Prof. A. S. Eddington, professor of astronomy at Cambridge University, England, in a letter to *Nature*. Referring to the article written for *Science Service* by Dr. Ludwik Silberstein, mathematical physicist of the Eastman Research Laboratory at Rochester, following Prof. Miller's presentation of his results at the recent meeting of the National Academy of Sciences at Washington, Prof. Eddington says, "The brief messages in regard to Prof. Miller's experiment have aroused much interest and bewilderment; it is therefore of great value to have Dr. Silberstein's authoritative account."

Prof. Miller's experiment was a repetition of one originally performed by Dr. Albert A. Michelson, now at the University of Chicago, and Prof. Edward Morley, by which a beam of light was divided into two parts and reflected back and forth in directions at right angles to each other. They were then reunited and a series of light and dark bands resulted. From the position of these bands the physicist can tell which beam takes the longest time to return. When first performed, in the basement of the Case School, Cleveland, in 1887, no effect was obtained, but when he repeated it last summer at Mt. Wilson, Prof. Miller obtained a marked effect.

Prof. Eddington disagrees with Dr. Silberstein's interpretation of the new experiment as indicating that the ether, by which light is supposed to be transmitted, is gliding over the earth with a speed which varies from about zero at sea level to about six miles per second at the altitude of the Mt. Wilson Observatory. "There is thus," says the Cambridge astronomer, "a rapid rotational motion of this part of the ether."

In order to account for the astronomical facts, however, this motion must be the same at all levels, he continues. Just as a boat set to steer a straight course would be turned to one side if it entered a current of water moving at a different speed, a ray of light which is vertical at the level of Mt. Wilson would be inclined a small amount at sea level, and the direction in which it is inclined would vary according to the time of day or night. The amount of inclination would be about 7 seconds of arc, but astronomical observations capable of detecting a much smaller deflection have never revealed any such discordance of positions of stars as seen from sea level and mountain observatories.

"The Michelson-Morley experiment," Prof. Eddington concludes, "was originally performed because it was thought—mistakenly, as we now realize—that it would measure absolute ether drift. In the new application, it is invading a field in which the facts have long been established by delicate observations and it is difficult to regard it as a serious competitor."—*Science Service.*

New Elements Discovered by Use of X-Rays. Use of spectra obtained by passing a beam of X-rays through concentrated solutions of rare minerals have enabled Dr. Walter Noddack, of the University of Berlin, assisted by Otto Berg and Ida Tacke, to discover the missing chemical elements number 43 and 75, in the group with manganese in the periodic table. Traces of them have been detected in the concentrated solutions of platinum ores and of the minerals gadolinite and columbite, and it is estimated that they form a billionth of the earth's crust. Dr. Noddack has named them masurium and rhenium after the territories lost by Germany as a result of the peace treaty, the Masurian region of East Prussia on the east and the Rhine provinces on the west.—*Science Service.*

SOME SUGGESTIONS AS TO THE SELECTION OF A LABORATORY MANUAL FOR HIGH-SCHOOL CHEMISTRY

W. G. BOWERS, COLORADO STATE TEACHERS COLLEGE, GREELEY, COLORADO

If the chemistry teacher on entering a new position sees fit to change laboratory manuals or adopt new ones to begin with, he looks for a manual containing a suitable number of experiments which fit into his plan. If he wants sixty experiments and can get a manual containing sixty, all of which are suitable to his plans and conditions, so much the better, but probably this would be one case in a thousand. So it is always better to look for one containing many more experiments than are needed, even though it does cost the student a little more. If this is done, there is not so much probability that a change in teachers will necessitate a new adoption. Then if the same teacher wants to select a supplementary set of experiments for the more advanced students he can do so. All things considered, a manual which has fifty to one hundred per cent more experiments than are necessary in the course planned should be chosen. The question of prime importance is, does the proposed manual contain a sufficient number of experiments which conform to the ideals of the teacher. Other conditions, *e. g.*, the arrangement of the experiments in a certain order to accord with the text used, etc., are of comparatively minor importance. The teacher himself can modify the order. This requires but a few hours of his time after he has fixed in his mind the order which he desires to follow. It requires only a few minutes of the students' time together with that of the teacher to make a list of the new order of experiments or to check the experiments with new numbers.

In the organization of laboratory work, after the character of the work has been decided upon and a suitable manual chosen, one thing must be remembered; namely, that a definite order of experiment should be followed. Different orders for different groups of students should never be employed, as is done in some poorly equipped high schools. This procedure spoils any attempt at correlation between laboratory and lecture work, by destroying the logical order of experiment. The arrangement referred to is this: one set of apparatus is arranged at each desk, experiment number one is arranged for at desk number one, experiment number two at desk two, and so on; student or group number one starts with experiment number one and, when that experiment is finished, moves ahead to number two, and thus progresses until the course is completed. This means that group number fifteen starts at desk fifteen and progresses to the last experiment, then comes back to number one and progresses to fifteen. Such an arrangement makes it impossible to carry out the good pedagogy which has been planned, occasions unnecessary inconvenience in the handling of materials, and handicaps the instructor considerably in his laboratory supervision.

It costs only a little more for apparatus and no more for materials to arrange for each student or group of students to remain at the same desk, doing each experiment in its order from first to last in the properly classified list.

In determining the order of experiments we encounter almost the same problems that we had to deal with in considering the character of experiments in general, but in a more difficult phase. It is not as hard to decide what a beginner should have the first year as it is to decide what he should have the first week, after it is settled what he should have during the first year. It rather seems as though (if he should have fundamentals the first year) he should have fundamentals of fundamentals the first week. This principle would apply of course to the building of any sort of structure. The first part of the foundation should be the footing. We should accept this as a general truth, but there is such a thing as making the work easier by pouring the materials on the more convenient level and letting them run to the deeper ones. W. Segerblom[1] saw the necessity of pouring the material on the more convenient level and letting it run to the deeper places when he said, "Avoid starting the student on theories which took the teacher himself years to demonstrate, but start the student in the accumulation of simple facts and give him an acquaintance with simple substances." He also says that if we do not do this the student is in danger of accepting general principles without working to prove them. But if the student accumulates the facts in order to arrange them in logical sequence he will reach out for the general principles.

Segerblom's pedagogy can be applied in each separate week's work if not in each separate day's work, if the manual lays out the directions properly. According to this plan it would be necessary to complete the list of familiar solids before taking up a study of the gases. It would not be necessary, however, to take the familiar metals, copper, iron and zinc out of their setting in the general structure. As is now directed in the most approved manuals—such as McPherson and Henderson, Newell, Brownlee and others—copper, iron and sulfur can be employed in discovering a collection of facts which will lead to the development of the general principles differentiating elements from compounds, elements from mixtures and compounds from mixtures.

Alexander Smith,[2] recommends the study of gases first in high-school courses in order that fundamental relations may be earlier and better established. He says also that since we must become acquainted with homogeneous solutions, elements, mixtures, atomic and molecular weights, we should deal to some extent with solids, especially sulfur and the familiar metals.

[1] *School Sci. & Math.*, **10**, 18 (1910).

[2] "The Teaching of Chemistry and Physics in Secondary Schools," Alexander Smith and E. H. Hall. Longmans, Green & Co., New York City, 1902, p. 54.

The study of oxygen and hydrogen in the manner in which it is taken up in the most approved manuals meets the above-mentioned requisites, and also those advocated by Segerblom, in that facts which lead the student to conclusions regarding combustion, heat of decomposition, and heat of composition, are accumulated.

Kidzie recommends beginning with the easy and familiar things, and suggests that the beginner study oxygen in one of his first exercises. Experiments with oxygen certainly have been found excellent for the beginner. The preparation of oxygen and the collection of the gas over water is not so easy as some experiments, but the average student will fit up the apparatus ready to collect a gas in thirty minutes, he will do it with comparatively little help from the instructor, and he will be proud of his job. If the student prepares his oxygen from potassium chlorate, he may not think of it as the familiar substance existing in ordinary air, but a slight suggestion will make him realize that he has before him that same familiar substance. Nothing could appeal to his desire for the familiar in a stronger way.

R. H. Bradbury[3] says: "Do not begin with oxygen and hydrogen even if you do electrolyze water to obtain them." Students cannot see that water disappears. They do not understand the addition of sulfuric acid. He says, "Begin with copper and sulfur, taking small amounts which will disappear and form a new substance which is tangible." Bradbury probably means, use these familiar solids for the first couple of experiments or for the first week or so and then take up oxygen and hydrogen. If we give Bradbury's suggestion this interpretation we have his approval also on the order given in the most popular manuals.

Bradbury again in a later article[4] agrees with Segerblom, when he says: "Do not give principles and then demonstrate." The student will wonder why we do not take the principles on faith. He says: "Go from actualities in common experiences to principles. Take for example Boyle's Law. Give a student some glass tubes, some water and some mercury and ask him to prove the validity of Boyle's law. He is as likely to arrive at the proper result as if he took a sack of type and shook them out over the holders and found them spelling what he had in mind."

L. F. Swift[5] is advocating the same pedagogy when he says: "Teach the theory of ionization by having the students begin with some conductors which have distinctive colors, like copper nitrate, copper chloride and copper sulfate, and when electrolyzed, give copper with its characteristic color, different from that of either of its salts. Then have the student compare these with some nonconductors. Then have them study the dif-

[3] *School Sci. & Math.*, **15,** 782 (1915).
[4] *Ibid.*, **17,** 25 (1917).
[5] *Ibid.*, **18,** 46 (1918).

ference in the lowering of the freezing point and the raising of the boiling point by the same amounts of electrolytes and non-electrolytes. Then define ion." Swift does not say that these experiments should be among the first given but uses these to exemplify the method of passing from fact to principle in series of experiments.

What has been practically agreed upon for the first year's program, and almost unanimously agreed upon for the first week's, *i. e.*, that fundamentals should come first, has not been contradicted by the proposition that the beginner should first get facts and then reason from facts to principles. A fair compromise on what sort of experiments should come at the very beginning and what sort should follow in the first year's work does not at all prevent adherence to this principle. The idea of doing the most familiar and least difficult experiments first, and gradually passing toward the least familiar and more difficult, does not necessarily mean a wholesale scrambling of the scientific classification of the elements and their compounds.

Of course some of the metals near the last in the periodic table are more familiar than are some of the non-metals which fall in the earlier part of the table, but we have seen how the more familiar properties of these metals can be used in the illustration of fundamental principles and the less familiar and more difficult studies concerning them can be left to their proper places in the periodic classification. Thus a well rounded course for beginners can be made to pass from fact to principle, from easy to difficult, and from familiar to unfamiliar.

H. N. Goddard[6] in discussing manuals expressed himself as being glad to see the time coming when methods will be chosen with a view to previous experiences of the student and to natural processes of thought in young minds rather than with a view to what has been determined as scientific by experts and specialists. We agree with this because we have had too much sad experience with students losing interest by trying to perform experiments which involved too intricate apparatus with too meager directions.

But the opposite extreme has been advocated and tried. For several years it was considered wonderfully successful for the reason that directions were so elaborate that nothing was left for the student to do but fill in the blanks with yes's, no's and figures. This made it easy for the instructor to examine and correct notebooks. It made it easy (too easy, in fact) for the student to complete his notes. This was called the "Recipe Method." We are glad now for the student's sake that the Recipe Method is being abandoned. For his sake we should avoid the type of directions which calls for no thinking but simply the mechanical following of instructions.

[6] *School Sci. & Math.*, **16**, 710 (1916).

We should also avoid too meager directions and questions which compel the student to depend entirely on guess work. This phase of laboratory instruction is so vital that we feel justified in elaborating on one example. An experiment proving the validity of Charles Law serves as a good one. Suppose the student is asked to prove the validity of Charles Law and given the following directions: "Take the temperature of a flask of air at about 75°C., then cool the flask to about 25°C. Let water into the flask to take the place of the diminution of volume of air. Weigh the water and thus calculate the amount of decrease in volume of air compared with the decrease in temperature." With such directions the instructor would have to help every student or group of students with every step of the experiment, and then help him to arrive at his conclusions. In order to enable the student to complete, and gain a thorough knowledge of the experiment, the instructor would have to give his entire time to four or five students throughout the laboratory period. To illustrate the opposite extreme we could take the same experiment. We could fill two pages with detailed directions, leaving blank spaces for figures and substitutions in formulae.

Students' directions should strike a mean between these extremes. They should be only elaborate enough to enable the average student to think his way through and solve his problem by drawing upon his own resources.

If in selecting a manual the chief consideration is given to a sufficient number of the proper kind of experiments, it may not be difficult to adjust the order to suit our particular case but it will very likely happen that in the directions for each experiment there will be too little or too much said. In this respect the teacher will have the greatest opportunity to show his originality. To encourage the best habits of thinking on the part of the students, the manual directions had better be too meager than too elaborate.

To sum the matter up in as few words as possible, the manual should have:

First: More than sufficient experiments for the course.

Second: Experiments of a character suited to the ideals of the teacher.

Third: Directions which are not so elaborate as to deprive the student of the pleasure and benefit of thinking out his own problems in his own way.

BALLAD OF RYERSON

EDWIN H. LEWIS

Lo, Paris and Cambridge and Ryerson were needed to make one thought
Till on the final droplet-star, the massiest, tiniest sphere,
The moon-grain lingered a moment and told the secret here.
Now take the charge and the crystal! Young heroes, unlock the lead,
And kindle a rose for mother ere the rose of her hearth be dead.

O planet, ridged with Calvaries and rimmed with Suvla Bays,
Not all your nights are reined with fire, not all of your lightning slays,
Then why have you slain your darlings? And why did your heart disclose
Fury and flame and the flash of lead when your dearest brought you a rose?
Ah, the rose! The expectancy and the rose!
The beat of the harp is broken, the heart of the gleeman is fain
To call him back from the grave and rebuild the shattered brain
Of Moseley dead in the trenches, Harry Moseley dead by the sea,
Balder slain by the blindman there in Gallipoli.
No longer the towers of Oxford whisper the middle age,
But the dearest of hopes destroyed and the great unwritten page.
No longer the Trinity meadows bloom as in other days
But the sunlight dreams of violets beyond the violet rays.

Beyond the violet seek him, for there in the dark he dwells,
Holding the crystal lattice to cast the shadow that tells
How the heart of the atom thickens, ready to burst into flower,
Loosing the bands of Orion with heavenly heat and power.
He numbers the charge on the center for each of the elements
That we named for gods and demons, colors and tastes and scents,
And he hears the hum of the lead that burned through his brain like fire
Change to the hum of an engine, the song of the sun-grain choir,
As it spins the chaliced lightning to banish shadow and shade,
Or drives the heavy hammers by the sun-grain cannonade,
Or wears the wings of the humming birds that flash through heaven afar,
Or grinds the golden barley by the voltage of a star.

Now, if they slay the dreamers and the riches the dreamers gave,
They shall get them back to the benches and be as the galley slaves.

CLASSROOM EMANATIONS

Organic is the living germs in water and inorganic is the dead ones.

A gas is a dry liquid.

A salt is a substance which has been naturalized.

When heat is applied to a gas, the molecules are stimulated to get away from the heat.

A calorie is the amount of pressure required to push 1 gm. of water 1°C.

Molecules bump together and cause the molecular hypothesis.

Each molecule moves on its own track.

(By a Chinese student.) The properties of CO_2 are, can't smell, can't see, little white.

The phlogiston theory is a theory that used to be believed by chemists and people.

The electrochemical series is a series of substances arranged so that the metal above will displace hydrogen from the metal below.

Ammonia is sometimes called spirits of shorthorn.

Ordered at the stock-room: lighted splinter, methyl group, hydrogen-ion, violet vapor.

A catalyst is a substance which felicitates a chemical change but does not change itself.

Pure substances are those which do not contain any organic or inorganic matter.

A solution is a liquid containing a solid which may or may not be soluble in it while a suspension is the state of a solid being insoluble in a solution.

When lighted, the hydrogen squealed.

A moral solution is one which contains one g.m.w. per liter.

The late heat of vaporization is that which comes after the substance vaporized.

Calcium chloride is a very thirsty substance.

Nascent atoms are equipped with arms, with which they can combine with other atoms.

The iron combined with oxygen, forming a brilliant spectacle.

The difference between a physical and a chemical change is that a chemical change evaporates and a physical change remains the same.

An example of efflorescence is wet clothes and of deliquescence is soda crackers.

Ozone is made by passing a spark plug through air.

Electrolysis is the passage of an electrified wire through water.

To distil gasoline from crude oil, place the crude oil in a flask, connect it with a distillate and heat.

The chief products obtained from the destructive distillation of coal are toluene, benzene and nitroglycerine.

Sulfurated hydrogen is a gas of pugnacious odor.

Chemical Digest

ABSTRACTS

Note on the Sealing of Carius Bomb-Tubes. THOS. ROBT. JACOBS. *Chem. News*, **130,** 328 (1925).—The method suggested for sealing the tubes consists in first heating the tube at the open end in a luminous flame until hot and then increasing the temperature to a maximum. While rotating the tube the heating is continued until the sides have fallen together and the opening is almost closed. Then directing the flame at the end, a thick walled tube of 8 mm. external diameter is sealed on to the bomb-tube, its bore corresponding with the aperture. Finally the tubes are withdrawn from the flame and the upper end of the bomb-tube drawn out into a capillary, which is then sealed off.

But little experience is necessary to carry out the operation. The amount of glass drawn off at each seal is very small, so that a bomb-tube 50 cms. long can be used for six to eight analyses. The wall of the capillary seal obtained is at least as thick as that of the main tube.

E. G. VANDEN BOSCHE

Some Recent Representations of the Periodicity of the Elements. J. G. F. DRUCE. *Chem. News*, **130,** 322–6 (1925).—Attention is called by the author to a few schemes that have been put forward recently to express the periodicity of the elements. The spirals of Nodder, Partington and Tansley, the wedge of Loring and finally the sphere of Friend are commented upon and figures of each are given.

E. G. VANDEN BOSCHE

The Training of Chemists in the University of Minnesota. NORVILLE C. PERVIER. *Chem. Bull.*, **12,** 85 (1925).—Data are given from a survey including 320 alumni of the institution who have completed their training for chemists in the past twenty-eight years.

Of these people 29.2% are found to be what are called chemists, 19.6% are teachers, 40.9% are in chemical professional work and but 10.3% in non-chemical professional work. It is remarked that but 1.2% of the teachers are teaching in high schools, all the remaining teachers are college teachers.

The growth of the graduate work in chemistry in that university is measured by the fact that the total number of degrees granted for the five-year period ending 1909, is 32 and of these 2 were masters and none doctors.

	Total	Masters	Doctors
1914	94	19	3
1919	84	21	10
1924	180	42	18

B. CLIFFORD HENDRICKS

The Care of Student Health. ANON. *Technology Rev.*, **27,** 123–7 (1925).—This article describes what Mass. Inst. of Tech. is doing in caring for the health of its students.

Three first aid rooms are provided. The Department of Hygiene, as now constituted, comprises the Head, with the title of Medical Director, two associate physicians, a secretary, a nurse and, in the gymnasium, a leader highly skilled in corrective gymnastics with a secretary and a technical assistant. In addition, certain of the coaches of the athletic teams are affiliated with the Department although not under its immediate jurisdiction.

Every man entering Technology is required to have a complete physical examination. One out of every five of the men examined has something the matter with him.

Special stress is laid on instructing students how to live, what to eat and how to preserve health.

Last year 11,906 visits were made to the health clinics, or an average of four per man. Beginning with the class of 1925 it will also be compulsory that all seniors be examined.

S. W. HOYT

Anecdotes about Mysterious Explosions and Fires. AUGUSTUS H. GILL. *Tech-*

nology Rev., **27**, 138 (1925).—Dr. Augustus H. Gill relates several very interesting cases of fires starting mysteriously; in most cases the most probable cause of the spark causing ignition being frictional electricity. S. W. HOYT

The Possibilities of a "Burned Out" Electric Light Bulb in General Science. ELLSWORTH S. OBOURN. *Sch. Sci. Math.* **25**, 516–21 (1925).—Suggestions for the general science teacher in small, poorly-equipped high schools.

The brass shell may be removed by gently warming to melt wax with which it is sealed on. Glass shoulder may be removed by careful nicking with file. Resultant vessels may be used in lieu of Florence or Erlenmeyer flasks or even as ignition tubes. (Heat-resisting qualities are excellent.)

O. also gives directions for the construction of simple apparatus to demonstrate weight of air, air pressure, air thermometer, aneroid barometer, fire extinguisher, etc. O. R.

A Ninth Grade Course in General Science. WINIFRED PERRY AND KATHERINE OWENS. *Gen. Sci. Quarterly*, **9**, 231–49 (1925).—A detailed outline with the following main headings: I, The Air; II, Clothing; III, Water; IV, Earth. A list of supplementary reference books is appended. O. R.

One-Movement Process for Impregnating Timber with Zinc Chloride and Petroleum Oils. A. M. HOWALD. *Wood Preserving News*, **3**, 26–7 (1925).—The various combination treatments of wood with zinc chloride and petroleum oils developed during the past twenty years have one disadvantage, namely, the time and manipulation required for separate treatments. A process worked out at the Mellon Institute of Industrial Research of the University of Pittsburgh combines the two treatments in one movement.

Asphalt residuum and distillate fuel oils are mixed in proportions to give a suitable viscosity, and agitated with from 15 to 25% of a 10 to 40% solution of zinc chloride. When pumped at high pressure (2000 lb. per sq. in.) and at a temperature of about 170°F. through an emulsifying valve an emulsion fine enough to impregnate wood fibers is obtained. The natural emulsifying properties of the asphaltic oils keep the emulsion stable. The usual pressure impregnation processes are applicable to this emulsion process, the temperature used being from 170° to 180°F. In coöperation with the Santa Fe R.R., pine, gum, and red oak ties have been successfully treated. It is believed that such treatment will protect wood throughout its mechanical life. CHAS. E. DULL

The Use of Text Book and Syllabus Courses in General Science. FRANCIS D. CURTIS. *Sch. Sci. Math.*, **25**, 495–9 (1925).—An analysis of instruction material employed, based upon replies to a questionnaire sent by the author to 206 specially selected high schools throughout the country; said high schools being those which seemed most likely to represent the best equipped, most ably instructed, and most progressive secondary schools. Eighty-four replies tabulated. Thirty-one % reported the use of one text, only, unsupplemented. Twenty-five % used one basic text, supplemented by magazines or other materials (not texts). Twenty-five % used a course based upon required portions of several basic texts.

The number of schools using some sort of syllabus is surprisingly small, especially in view of the fact that the majority of the department heads state that a syllabus is preferable to the unsupplemented text. "If this is the case in these 'best' high schools, what must be the conditions in some of the smaller, less favored districts?"

The principal reasons for this condition may be outlined as follows:

1. The lack of funds to provide necessary material
2. Conservatism and inertia
3. The heavy teaching load
4. The more or less general distrust of a syllabus course, per se
5. The administrative difficulties arising in the transfer of students.

C. suggests that some of the advantages of a syllabus course may be obtained as follows:

1. By supplementing the work in the textbook with references to other books or publications in the school or town library or which may be borrowed from patrons of the school.
2. The pupils may be encouraged to donate to the department of science, magazines in which they find scientific articles.
3. The pupils may be induced to contribute a small sum each term for the specific purpose of adding to their science library.

"In no school are the actual and potential resources for syllabus building in general science so meagre and unpromising as to make impracticable *some* sort of syllabus." O. R.

Effect of Methods of Instruction upon Character. MILTON FAIRCHILD. *Nev. Educ. Bull.*, **7**, 14 (1925).—Criticism is made that too much of the quiz method is used, that it stimulates guessing for the answer without giving a chance to classify or interpret data. "What method of instruction produces the best intellectual character" is suggested as a fitting subject for research and a list of "desirable intellectual characteristics" which defines the question is appended. G. W. SEARS

Research in the University of Virginia. RESEARCH COMMITTEE OF THE UNIV. OF VA. *Bull. Amer. Assoc. Univ. Prof.*, **11**, 124 (1925).—The committee does not favor what are called "research professorships." Instead, it feels that "research may fructify instruction and instruction illuminate research." It warns that there are two dangers to be avoided: mistaking publicity for research and restricting the term research too narrowly in its meaning. Research is defined as "those activities constituting the natural expression of the aims and interests of scholarship." It says: (1) "that differences of kind in natural aptitude" of different faculty members must be recognized; (2) "that research is a function coördinate with instruction and administration;" (3) that practical considerations determining research in different departments will vary; (4) that specialization of research for some few individual members of a teaching staff should not be permitted to suggest antagonism between instruction, research and administration for the group as a whole.

For reasons cited in the article, it is desirable that each member of the faculty should "be investigating in the field of his major interest and contributing ideas and methods to its development."

Among the recommendations made are: (1) that research interest and productivity be considered as a factor equal in importance to instruction and administration as a basis for promotion. (2) That administrative and committee work of faculty members actively engaged in research be reduced to a minimum. (3) That increased facilities for publishing work done for which no channels for publication are now open, be provided. (4) That steps be taken to relieve the teaching staff from tasks of a clerical nature, that such time may be devoted to research. B. CLIFFORD HENDRICKS

How to Make a Chemical Flask Motor. EARLE R. CALEY. *Experimenter*, **4**, 537–8 (1925).—"A novel and unusual heat motor that really works and is easily made from some flasks, a few pieces of glass tubing and some wood, is shown in the illustrations which accompany the article. Small chemical flasks are mounted upon the ends of some straight glass tubes which are fixed to a revolving shaft. The ends of the glass tubes reach nearly to the bottom of the flasks. The flasks contain some volatile liquid such as ordinary denatured alcohol, ether or acetone. When heat is applied to the flasks on one side by a Bunsen burner, the pressure of the liquid vapor in the heated flask forces the liquid over to the flasks on the opposite side, over-balancing the system and causing the whole to rotate. This action is fairly rapid."

The details for the successful construction of the motor are given. O. R.

Chemical Spelling Continued. C. A. JACOBSON. *Science*, **61**, 590 (1925).—"Chemical spelling is now in its fourth year at the West Virginia University. Over three hundred students have entered the spelling matches each year...

"Several other institutions are now beyond the experimental stage in chemical spelling, and in at least one section of the country, namely, the southwestern, intercollegiate spelling matches have been held. The progress of chemical spelling has been retarded to some extent by the fact that no suitable list of words and formulas was available in print and therefore had to be prepared."

The author has prepared "A *Pronouncing* Chemical Formula Speller," which appeared about April 20. It includes about 3000 inorganic and 1000 organic compounds, together with about 300 of the more common minerals. The 1925 International Atomic Weights and Atomic Numbers of the elements have been included. O. R.

Classification and Eligibility. S. L. REDMAN. *Chem. Bull.*, **12**, 167–8 (1925).—"The term 'chemist' does not carry with it the prestige or professional standing associated with such terms as engineer, lawyer, or doctor (M.D.). Because of this fact, the remuneration received by chemists is much less, on the average, than that received by those of corresponding academic training and experience in other professions... Coupled with this is the further fact that a lack of clear understanding on the part of the public of the meaning of chemistry has led to the abuse of the term 'chemist' both in and out of the profession which has tended further to lower its standing.....

"In the past, two remedies have been proposed for this situation both of which

the chemical profession as a whole has refused to accept. The one is the closed shop-labor union idea; the other the State license plan. Either of these probably could be effectively employed if the majority were to agree upon their use. The remedies recently proposed do not seem either to be effective in accomplishing the purpose, or to be directed to the seat of the trouble.....

"Twenty years ago, or even less, in almost every town of any size were so-called medical colleges turning out men probably as well (or poorly) qualified to practice medicine as are the B.S. graduates of our average college and university courses to practice chemistry. Does not the remedy which cured this condition suggest to us a remedy for our own troubles?....."

The author suggests the establishment, at every large university, of a School of Chemistry to correspond with Schools of Medicine, Law, etc. For graduation he would require a four year course leading to a "B.S. in Chemistry," corresponding to present engineering degrees. A year's additional work, accompanied by a thesis, after a lapse of several years spent in practical chemical work, might then entitle him to a degree of "Master of Chemistry" or "Chemist."

This could be followed by the usual graduate work, leading to the degree of Ph.D. or "Doctor of Chemistry." References in chemical literature and want ads in chemical journals should restrict the term, *chemist*, to those fulfilling the requirements outlined, using the term, *technician*, for others employed in chemical work.

The A. C. S. could appoint a committee of prominent members to annually inspect and classify the "Schools of Chemistry" into Grade A and Grade B schools. Pre-chemical work should also be passed upon. O. R.

The British Association of Chemists—The Title Chemist. H. T. F. R. *Chem. Age*, **12**, 501 (1925).—"Despite the proverb, it is occasionally emphatically true that a name is a very important matter indeed, and this, to the uninitiated, trivial question was one which had a large share in bringing into existence the British Association of Chemists....

"The energetic propaganda that the Association has carried out in this direction has done much to enlighten the public regarding this term, but it is our common experience to discover well-informed persons who still confuse the chemist with the pharmacist, and who at best suppose that the technical chemist is merely a pharmacist who has carried his training a little farther than the ordinary chemist and druggist....

"It has been and still remains, the Association's aim to legalize the term chemist in such a way that it shall not be applied to any who are not recognised as properly qualified in chemical science. The question is, however, one which bristles with difficulties, since the title "Chemist and Druggist" is one which the pharmacists have a legal right to use, and any attempt to insist that the pharmacist should cede the former is, by reason of established tradition, difficult to press....

"The term 'qualified chemist' has at present no exact meaning except so far as it applies to the pharmacist, and it is very difficult to decide under what terminology the chemical profession can be legalised if the term chemist is denied to it.

"The executive of the Association believes the true obstacle to be the fact that the profession of chemistry is not united, and that an organized body such as the pharmacists feel disinclined to enter into negotiations which may not be binding upon all the members of our profession. This is yet another aspect of the argument for unity.

"The Association cannot deal with any universal question where it has not the support of the large majority of qualified practitioners, and it appeals to all such to support it in every possible way." O. R.

A Simple Toepler Pump. J. R. NEWSON. *Experimenter*, **4**, 550 (1925).—N. describes a pump, constructed chiefly of barometer tubing, which can be made by anyone with a little facility in glass-blowing. It is claimed to be slow but highly efficient. Diagram of apparatus and details of its operation are furnished. O. R.

Symposium Chemical Warfare Service. B. E. SCHAAR. *Chem. Bull.*, **12**, 101 (1925).—(Note—What shall be the chemistry teacher's attitude toward the chemical Warfare Service? The chemistry teacher's position upon this important matter is more vital to our nation's future than is that of the research or industrial man. The teacher has, through his students, opportunity to wield an influence, that cannot be safely overlooked. Mr. Schaar is only one of a number of contributors to the symposium under review.)

"I am in agreement with the Chemical Warfare program (but) let us consider an additional idea. Clearly, our object is to preserve the peace of our country.... We should approach this task in true research fashion—by first clearing our minds of all prejudices and preconceived ideas.

"Before the war, the world was alarmed at the militarism of Germany... We entered the war to end this menace to the peace of the world. Some of the outstanding lessons of the war are: armaments do not prevent wars and do not win wars, but conversely, the competition in armaments is actually an incentive to war." There is a grave danger that preparedness for defense will degenerate into preparedness for war.

We should bind our efforts toward, not only, new methods of defense but also the establishment of effective tribunals for the peaceful settlement of international disputes. To do this let us get behind "movements toward international comity."

It is suggested that the A. C. S. reorganize its committee under the name of National Defense Committee with two main divisions: first, Chemical Warfare Service and second, International Relations. These two committee divisions would organize separately but would by coöperation push toward the desired end.

B. C. HENDRICKS

Teaching Temperature Effects to Elementary Students. R. A. BAKER. *Sch. Sci. Math.*, **25**, 628–30 (1925).—Students are interested in the subject of temperature effects by being asked to list natural changes they have observed in which temperature affects the rate of change. This preliminary report is followed by an experiment in which approximately 10 gms. each of NH_4Cl and $NaNO_2$ are placed in the bottom of a 500 cc. Erlenmeyer flask and covered with water. Evolution of N_2 is started by cautious heating over burner. Since the reaction is exothermic, it may be alternately retarded or speeded by immersing flask in cold bath and withdrawing. Quantitative relationship between temperature and rate of reaction may be nicely illustrated by means of $KBrO_3$ and HI reaction in presence of starch soln. (Noyes and Blanchard, *J. Am. Chem. Soc.*, **22**, 742 (1900).)

O. R.

A New Acid-Resisting Material. J. H. WEST. *Chem. Age*, **12**, 522 (1925).—The author describes a new acid-resisting pitch-concrete, "Prodonite," developed by a Swiss company. A special very hard pitch is employed as a binder with a graded, acid-resisting mineral aggregate. The material may be reënforced like ordinary concrete. Compressive strengths of 6000–7000 lbs. per sq. in. can be easily obtained and tensile strengths of 1000 lbs. per sq. in. have been attained. The material has a smooth black surface and remains non-plastic at the temperature of boiling water. It is completely resistant to all dilute acids, to concentrated HCl and to most other chemical reagents.

O. R.

Too Many German Chemists. (Editorial.) *Chem. Age*, **12**, 519 (1925).—The German Chemical Society has issued a warning, directing attention to the very large number of chemical students in the universities, and the increasing difficulty in finding suitable employment for young chemists.

"The extent of unemployment among German chemists today may be roughly gauged from the fact that for every opening advertised there are 150 to 200 applicants, the majority of whom are presumed to be unemployed."

Foreign fields are largely closed since the war, due to political and sentimental prejudices.

"In order that the economic position of the young German chemist may be to some extent assured, it is necessary to reduce the number of university chemical students below the pre-war level, *i. e.*, to about one-third of the present number." O. R.

Aspects of Practice-Teaching in the Preparation of Chemistry Teachers in a State Normal School. J. O. FRANK. *Ed. Adm. and Supervision*, **11**, 157–66 (1925).—The Program of Teacher Training in Chemistry in the State Normal School at Oshkosh, Wisconsin, is distributed among four groups of subjects. One hundred forty-four hours are required for graduation and are distributed as follows:

I.	Foundation and Culture Group	20 to 40 hours
II.	Academic Subjects	65 hours
III.	Extra-curricular training	variable
IV.	Profession Training	35 hours

The student's preparation in his major academic subject is equivalent to that required by the colleges for graduation. The 65 hours are distributed: Major—30 credit hours or three years; First minor, 20 credit hours or two years; second minor, 15 credit hours or $1^1/_2$ years. A typical program would include (1) chemistry, (2) physics and (3) mathematics. Professional training includes 16 hours of the usual professional courses and 19 (?) in supervised teaching. Supervised teaching is arranged in four successive steps. (1) Observation; (2) Apprentice work in which students become acquainted with physical equipment and its manipulation; (3) Apprentice teaching,

teaching small groups; (4) Supervised teaching; the student takes complete charge of a class. S. R. P.

Research Problems Presented by the Petroleum Industry. J. B. HILL. *The Catalyst*, **10**, 7 (1925).—Chemistry has not done as much for the petroleum industry as for coal tar, due in part to the changing nature of petroleum. Petroleum compounds are less reactive, more numerous and harder to separate than coal tar products. Being unimportant to Germany, German influence has been against their study, and many of our organic chemists received their training in Germany. Most work had been done on paraffin bases, while many of present bases are somewhat like low temperature coal tars.

Problems in gasoline industry are: (1) greater yield, (2) better refining and (3) more efficient use. Fundamental studies in cracking are needed to increase the yield of the desired molecules. Valuable materials are lost through the use of sulfuric acid but no other cheap polymerizer is available. Silica gel and fuller's earth are used to some extent. The lubrication problem calls for a great amount of work, as the oils from different crudes vary considerably. Detonation problems demand further study. The synthetic chemistry of petroleum has just been scratched. D. C. L.

Silicate of Soda and Soaps. *Silicate P's and Q's*, **5**, 6 (1925).—The type of soap that is used depends primarily on the nature of the substance to be cleaned. Much money is spent in advertising and telling prospective customers many things that have no bearing on the merit of the soap. "The lowest grade rosin soap can just as truly be said to be made from trees as the highest grade castile, so that the nature of the source is no guarantee of the finished product. Some experiments are cited to show that contrary to the general belief, a mixture of silicate and soap has greater cleansing power than soap alone, and that after 200 washings there was less weakening of the fiber in the silicate mixture than in the soap solution. In the first few washings there was an increase in strength, and after that a steady decrease, the fiber treated with the soap solution for 200 washings having a strength equal to about 72% of the original and that treated with silicate-soap solution was equal to 84%."

It was also found that the silicate solutions had less fading action on dyes. The mineral deposit which frequently forms after successive washings and ironing was found to have no deleterious effects on the strength of the fiber or the color of the dye. After 100 washings the ash content of the cotton had increased from 1 to 6.9%, but this deposit is soft and has no cutting action. D. C. L.

Properties of New Elements Predicted before Discovery. The new elements, masurium and rhenium, discovered by Dr. Walter Noddack in Berlin, were brought to light as a result of a law discovered by Henry G. J. Moseley, a young British scientist who lost his life in Gallipoli during the war. When a beam of X-rays is reflected by a crystal or powdered crystals it is spread out into a band, after the manner of a beam of light passing through a glass prism. If this band is allowed to fall on a photographic plate, a series of light and dark lines is obtained, which is called the X-ray spectrum. The X-rays have very short wave lengths and therefore come at the extreme end of the spectrum, beyond the ultra-violet waves.

After a study of the X-ray spectra of many elements, Moseley formulated a law which now bears his name, by means of which, if the atomic number of an element, or its position in the periodic table, is known, the character of its X-ray spectrum may be obtained. A few vacancies still exist in the 92 spaces of the table, but the characteristic spectra of the unknown elements can be calculated in advance, and when a substance is found to give this spectrum, there is no doubt of its identity.

Similar methods were used in 1922 by G. Hevesy and D. Coster at the Institute for Theoretical Physics at Copenhagen, to discover the missing element number 72, which was named Hafnium, after the Latin name for Copenhagen.

With the discovery of the new elements, there are only three vacant places left in the periodic system, which have the numbers 61, 85, and 87. These, like masurium and rhenium, which are numbers 43 and 75, are odd numbers, as it is a curious fact, pointed out by Professor Harkins of the University of Chicago, that in the case of elements of high atomic weights, those of even number are more common.

Noddack was trained under Nernst, the famous physical chemist of the University of Berlin.—*Science Service.*

Local Activities and Opportunities

Johns Hopkins. Two scholarships in gas engineering in Johns Hopkins University have been offered by the Consolidated Gas Electric Light & Power Company, according to an announcement. The scholarships, which are worth $350 a year each, are open to residents of Baltimore and vicinity who can meet the University requirements for entrance. Applicants may qualify for admission by graduation from an approved high school or by examination to be held September 14 to 17, 1925.

The appointments to these scholarships will be for one scholastic year. The holders will be eligible for reappointment from year to year if they conform in character, industry and ability with the standards and requirements of the University.

The course in Gas Engineering at Johns Hopkins University was originally established by the Baltimore company in coöperation with the Southern Gas Association. The Gas By-Products Laboratory of the University is probably the only complete plant of its kind in America and is available for research work for students desiring to follow gas engineering. The Department of Gas Engineering makes an especial effort to maintain intimate contact with the various gas and fuel industries in and about Baltimore, which has long been a center for advanced developments in this field. Coöperative arrangements permit the use of the facilities of several of these industries for instruction and research.

Chance for Chemical Engineers to Brush Up. Chemical engineers who have been out of college for some years and who feel the need to brush up on their fundamentals of chemical engineering methods, will be given the desired opportunity this year at the Chemical Exposition which will be held September 28 to October 3, at the Grand Central Palace, New York. A special course in chemical engineering which will be given in conjunction with the Exposition, will be divided into two groups. Section I for college students, and Section II for advanced students, graduate students, and engineers of industry who are desirous of reviewing their work. Lectures will be given by leading authorities in the various fields and will cover fundamentals and advanced work in engineering. Prof. W. T. Read, of Yale University, will have charge of the complete courses. Lectures will be held in the Grand Central Palace and tours of the Exposition for demonstrations will be conducted after the lectures. Entries for the course should be filed with the management, Chemical Exposition, Room 1102, Grand Central Palace, New York. The course is without charge.—*The Chemical News.*

Columbia University. Professor James Kendall of the Department of Chemistry returned on June 5 from a brief visit to Great Britain, in the course of which he delivered lectures on "The Mechanism of Ester Hydrolysis" before the Chemical Society of London and on "The Rare Earths" at the University of Edinburgh.

Harvard—Milton Fund Allotments. Twenty-one members of the faculties of Harvard University have been awarded allotments aggregating $44,000 from the Milton fund for the current year. This fund will yield $50,000 annually for research.

The members of the chemistry department to receive allotments with the purpose for which the allotment is awarded are as follows:

Gregory P. Baxter, investigations upon the density of gases, important in finding the atomic weights of the noble metals.

James B. Conant, investigations of the chemistry of haemoglobin, in the border-line field between organic, biological and electro-chemistry.

Grinnell Jones, apparatus required in research on the electrical conductivity of solutions.

"The allotments from this fund are to be used not to *reward* research but to *facilitate* it, and may not be used to replace or augment such instrumentalities for research as already exist."—*Harvard Alumni Bulletin.*

The Huxley Centenary. Celebrations at Kensington—The Huxley Centenary was celebrated on Monday (May 4), at the Royal College of Science, South Kensington, when a lecture was delivered by Professor E. B. Poulton. Professor Poulton dealt not so much with Huxley's great work, but with the remarkable gifts and characteristics of the man that made such success possible. Huxley is an outstanding example to young men of to-day as the personification of tenacity of purpose, courage, and vision, and only by assiduous perseverance in the face of depressing difficulties did he make his mark. With Professor Poulton were Sir Charles Sherrington (President of the Royal Society), Lord Buckmaster, Sir Richard Gregory, Sir Thomas Holland, Professor Bairstow and Mr. H. G. Wells. Mr. Herbert Wright presided.

The celebrations were continued in the evening at the Royal School of Mines, when a reception was held by Lord Buckmaster, chairman of the governing body, and Lady Holland, wife of the rector. The reception was followed by a conversazione.

Chemical Exhibit—The laboratories and rooms were filled with exhibits illustrating the work of the various departments of the three colleges. The chemistry section proved of great interest to the large number of visitors, the sections devoted to glass blowing, liquid air demonstrations and dyed flowers attracted many. The thiometer (making dirt talk), proved interesting; this instrument was recently used to detect 1 part of hypo in 5 million parts of water. The material to be washed, such as viscose, photo film, etc., is placed in a tank, the water entering the tank passes through a conductivity cell, while the exit water containing the dissolved salts passes through another conductivity cell. These cells form the two opposing arms of a Wheatstone bridge, and any alteration in the conductivity is transposed into sound by means of a loud speaker. Other exhibits depicted time reactions, Brownian movement, Vortex precipitation, Emotiometer—for registering the state of the emotions by the temperature of the hand—colloidal metals, mists in chemical reactions, showing the influence of small traces of acid in producing fogs.

The organic chemistry exhibit consisted of examples of research work and of specimens obtained in the laboratory and also those obtained on a semi-industrial scale in the Whiffen laboratory. The chemical technology section contained apparatus illustrating the processes involved in filtration and pumping, demonstrations of surface combustion, methods of nitrogen fixation, and the speed of flame propagation.

Items of music were rendered by the string band of the Scots Guards.—*The Chemical Age.*

The Eastman Gift. On December 8th, George Eastman announced the following gifts:

Mass. Inst. of Tech.	$4,500,000
University of Rochester:	
Eastman School of Music	3,000,000
College of Liberal Arts	2,500,000
Medical School	1,500,000
College for Women	1,500,000
Hampton Institute	1,000,000
Tuskegee Institute	1,000,000

Kansas. Constitution of the newly-organized Kansas Association of Chemistry, Physics and General Science Teachers.

ARTICLE I—NAME

This society shall be called the Kansas Association of Chemistry, Physics and General Science Teachers.

ARTICLE II—OBJECT

The object of this Association shall be the improvement of the teaching of science in the schools of Kansas, the promotion of the best possible correlation of science subjects with each other and with the other subjects of the curriculum, and the establishment of cordial and helpful relations among teachers of the Sciences.

ARTICLE III—MEMBERSHIP

1. Any person who is a member of the Kansas State Teachers' Association and is engaged in the teaching of Science may become a member.

2. Any person engaged in the supervision of the teaching of science may become a member.

ARTICLE IV—OFFICERS

1. The officers of the Association shall be a President, a Vice-President and a Secretary.

2. The duties of these officers shall be the duties usually devolving upon such officers. The officers shall constitute the Executive Committee of the Association.

3. The officers of the Association shall be chosen at the annual meeting. The vote shall be by ballot, requiring a majority of the votes cast to elect. These officers shall serve for one year and shall be the committee on program for the meeting of the association following their election.

4. Nominations for President, Vice-President and Secretary shall be made by a nominating committee of three appointed by the President.

ARTICLE V—MEETINGS

1. The annual meeting of the association shall be held in connection with the annual meeting of the Council of Administration of the Kansas State Teachers' Association.

2. The officers shall have the power to call a special meeting of the Association at any time or place. No action taken at a special meeting shall be binding on the general association.

ARTICLE VI—AMENDMENTS

This constitution may be amended at the annual meeting of the Association by a two-thirds vote of the members present, provided that notice of the proposed change shall have been published in advance of the meeting or given at the last regular meeting.

Nominations for officers for the ensuing year were called for and resulted in the unanimous election in each case as follows: J. A. Yates, President, Pittsburgh; K. O. Broady, Vice President, Sylvan Grove; Ray McClellen, Secretary, Lawrence.

A number of remarks by those present were then made as to what the organization might do to further the teaching of all the Sciences in the state. Some of the suggestions made were as follows: That written extracts of all papers and talks made at the Fall meeting and the February meeting be sent to all teachers in the state who desire them. That teachers in the state be requested to give papers and demonstrations of apparatus and methods used in illustrating difficult aspects of their subject. That all of the meetings not be given over to any one particular subject but that each science subject be given a place in each program.

Chicago Association of Chemistry Teachers. The closing meeting of the year consisted of a symposium on "Teaching the Scientific Method." Herbert R. Smith of Lake View High School, explained how it was possible, not only to teach the subject matter, but more of it and at the same time exemplify the Scientific Method to the pupil with its various phases of valuable mental exercise. Pupils are frequently not able to extend their knowledge of chemistry to useful ends because of a lack of training in thinking. For example, if ammonium chloride and calcium hydroxide have been used to prepare ammonia the pupil will have the idea that only these two compounds may be used. He should be asked to consider further if ammonium sulfate might be substituted for the ammonium chloride, and whether he assents or dissents the hypothesis should be tested by experiment so that he may find the way to truth for himself. Other possible substitutions for the ammonia salt and the hydroxide can be suggested and tested until sufficient data is collected as a basis for generalization on the principle of preparing ammonia

When this principle is established, it is put to immediate use by introducing the washing powder known as "Ammo." A little of it with water is found to produce ammonia gas. Then each pupil is asked to give in writing the probable composition of this Ammo powder, using the principle just learned. Each pupil that comprehends the principle will be able to give the correct answer with enthusiasm because of the new-found ability to see through things. The knowledge of the subject matter is firmly fixed by thinking through the various steps of the scientific method: gathering data, reasoning from fact, predicting results, generalization of principles and the application of them to new situations.

Dr. David Klein of the Wilson Laboratories and Dr. Freud of Armour Institute showed how this plan can be followed in presenting other principles of chemistry such as the preparation of acids, bases and salts. The general assent of the symposium was that pupils should think as suggested above rather than try to memorize chemistry.

University of Maryland. In conjunction with its annual summer school, the University of Maryland held, on June 26 and 27, a Symposium in Chemical Education, to which chemistry teachers of Maryland and the District of Columbia were especially invited.

The following subjects were discussed:

1. What are the Purposes in Teaching Chemistry? (General discussion.)
2. How to Teach Chemistry. (Class in action.) L. W. Mattern.
3. Experiences in the Correlation of High School and College Chemistry. C. E. White.
4. Teaching the Electron in High School Chemistry. M. S. Kharasch.
5. My Plans for the A. C. S. Prize Contest for 1926–27. (General Discussion, led by H. C. Brown.)
6. The Education of Industrial Chemists. Robert Calvert.
7. The Value of Fraternities in College. John H. Gardner.
8. My Experience with Chemistry Clubs at Winthrop College. Isabel McKinnell.
9. Presenting Chemistry to High School Students. Philip L. Robb.

South Dakota. The South Dakota Academy of Science held its tenth annual meeting on April 31st and May 1st and 2nd. The following papers were delivered: "The Development of Chemistry as Shown by the Evolution of Chemical Symbols." "Research in America," Dr. F. B. Dains. "Valley of Ten Thousand Smokes," L. A. Stout. "Regeneration of Animal Fragments," A. V. Arlton; "Pleistocine History of the Missouri River," E. P. Rothrock; "Relationship of Environment to Heredity," H. A. Hill; "Amphibians of South Dakota," E. C. O'Roke; "Bacteriological and Chemical Study of Silage," Charles A. Hunter; "Early National History Along the Missouri," Wm. H. Powers; "Phenomena of Inflammation," J. C. Ohlmacher; "Early Beginnings of Technical Chemistry in the Past," Dr. F. B. Dains; "A Case of Triple Chick Embryo," E. P. Churchill; "A Grasshopper Survey of South Dakota," H. C. Severin; "A Report on the Psychological Examination Given in the Higher Institutions of South Dakota," Wm. H. Batson; "A Factorial System for Use in Color Descriptions of Soils and Other Related Fields," J. Gladden Hutton; "Studies in the Saponification of Fats and Oils," R. G. Crosen; "Temperature as a Factor in the Lives of Fishes," A. P. Larrabee; "The Larger Structural Features of Western South Dakota," Freeman Ward; "Statistical Investigation of the Weather Reports," C. G. Stipe.

Recent Books

The Elements of Qualitative Analysis. W. A. NOYES. Seventh edition, revised, in collaboration with the author, by J. H. REEDY. Henry Holt & Co., New York, 1923. Pp. vi + 128. 13½ × 21 cm. $1.50.

The original purpose of this widely used manual, to provide beginners with explicit directions for manipulations, has been retained. The general form is that of the earlier editions. The directions for certain procedures have been clarified or amplified as a result of experience with large classes.

A few distinct departures from the procedures of the previous edition have been made. The cations of the tin sub-group are separated by ammonium carbonate and aluminum, a method which experience has shown to give better results in the hands of elementary students than separation by varied concentrations of hydrochloric acid. Nickel is tested for by dimethylglyoxime and cobalt by thiocyanate (Vogel's reaction) thus obviating the use of cyanide. Potassium is precipitated by perchloric acid and sodium by fluosilicic acid, only secondary importance being attached to the flame tests. In the detection of anions these are tested for, as far as possible, in the original substance without removing cations of heavy metals. The cations present having been determined, this information is combined with the solubility relations of the original substance to deduce what anions may be present.

The changes noted all make for increased usefulness and will be welcomed by teachers who have used the book in previous editions. Ionization, mass-action, the solubility-product principle and the colloidal state are briefly discussed in an introductory chapter. Reference to these matters is infrequent in the subsequent pages and their emphasis or omission left to the instructor's discretion. As in the earlier editions, the typography is excellent and errors notably few.

A. R. MIDDLETON

Chemistry Experiment Sheets. MARTIN MENDEL AND MILTON B. BRUNDAGE. Fordham Publishing Co., New York. 1924. 61 pp. 20.5 × 26.5 cm. $0.67; with binder plus $0.25.

Four pages are devoted to preface, index of experiments and diagrams of apparatus. The preface states that the experiment sheets are to be available in loose-leaf form whereas the volume submitted is in permanent binding.

The index to experiments shows 59 titles which include the more frequently used laboratory experiments for elementary general chemistry.

The directions for each experiment are printed on one side of the leaf, only, leaving a blank page opposite the directions for each experiment and it is evidently the intention of the authors that the blank page be used for answering the supplementary questions relating to each experiment.

The directions for performing a given experiment are clear and concise and it should be possible for most students to follow the directions without an undue amount of additional help on the part of the teacher. With each experiment is found a number of specific questions which call attention to the important observations to be made and the conclusions which should be drawn. In addition to the specific questions, there are a number of general questions relating to each experiment which are intended to bring out certain applications of the experiment in question. Some of these questions are pretty good. Most of them, however, can be answered by the average student only by reference to textbooks since they do not in most cases refer to actual experiences common to most boys and girls.

At the end of the book are six tables: symbols, valence, atomic weights of the more common elements, solubilities of common compounds, vapor tension, thermometer conversion table, metric-English equivalents and a valence chart.

The reviewer is unable to observe anything particularly new in these experiments. It would seem that the experiments should increasingly require more independent work on the part of the student if he is expected to gain as the result of laboratory experience. As a matter of fact, it appears that the student is given practically the same amount of detailed help in each of the experiments. In other words, the requirements placed upon the student do not increase in difficulty as he works his way through the list of experiments. Each experiment constitutes an additional accumulation of facts without provision for an increased independent laboratory ability.

HARRY A. CARPENTER

Biology and Human Welfare. J. E. PEABODY AND A. E. HUNT. Macmillan Company, New York. 1924. xii + 585 pages. 13.5 × 20 cm. $1.68.

A review of a text on biology may seem out of place in a chemical journal but this book warrants some mention here. The reviewer is no authority on biology so does not venture any opinions on the biological phase of the book beyond the statement that the motive of the text as set forth in the preface seems very sensible and the book looks very interesting.

Its particular value to chemistry teachers lies in the diagrams and the numerous references to chemistry. It should give the non-biological teacher of chemistry interesting and valuable side material.

The diagrams that caught the eye included: (1) storage and release of energy, (2) food manufacture, storage and assimilation, (3) per cent of alcohol in patent medicines and in liquors, (4) carbon cycle, and (5) nitrogen cycle. These diagrams are unusually good.

That the text is closely linked up with chemistry is further evidenced by the fact that eighteen of the 357 illustrations might be found in the usual chemistry textbook; one of them shows the interior of a chemical laboratory. A rough estimate shows that about one-sixth of the references in the Index are chemical in nature.

Sixty-three laboratory exercises are included and it may interest authors of chemistry texts to know that they "are included in the body of the book, because" to quote from the preface, "they constitute an essential part of the course and because they are more convenient for use here than they would be if placed in a separate volume or in appendices." W. SEGERBLOM

Rich's Chemistry Tests; Gamma and Epsilon Tests with Manual of Instruction for Giving and Scoring Tests. S. G. RICH. Public School Publishing Co., Bloomington, Illinois. 1923. 12 pp. 22 × 28 cm. $1.00 per 25 net.

Teachers who are burdened at frequent intervals with the heavy task of correcting large numbers of examination papers in chemistry, and who consider a saving of time and labor of primary importance, will be interested in any method of conducting examinations which promises to reduce the drudgery of correcting papers. Such a method is offered in the two tests mentioned above.

Quoting from the author's Manual, the chief points to be tested in chemistry examinations are: "ability to think, information, ability to solve problems, habits and knowledge acquired from work in the laboratory."

The content of the two tests is derived from material contained in five standard textbooks, twenty-five recent examinations given by the College Entrance Board and by the New York Regents, and from a number of state syllabi. No material has been used which was not common to at least two texts, or to a text and an examination and syllabus.

In order to avoid testing memory alone, the questions are arranged on the "cyclic principle" of Rugg as follows: thinking, memory, numerical, thinking, memory, laboratory. On each paper the time allowed for answering the twenty-five questions is twenty-five minutes. To each question four answers are appended. The candidate is told that one of these answers in each case is correct and is instructed to underscore that answer which he believes to be the correct one, an act which presupposes certain careful thinking or computation. Definitions are not required and equations are called for but once in both papers except as they may be incidental to the solution of a problem. The tests are stated to be applicable from the middle of the first semester up to the time when general chemistry branches out into specialized subjects. Other tests are stated to be in preparation.

As a brief and rapid method for testing attainment of students along certain lines and as a means of reducing the time usually allotted for examinations, these tests may prove satisfactory.

There is a point of view in regard to these tests, and to others of similar character, which ought not to be overlooked. The purpose of education is: first, to train the student's ability to think straight; and, second, to develop his powers of self-expression. In the older types of examinations, to which the College Entrance Board still almost entirely adheres, the student is required to express in his own language, without any suggestive appended statements, what he knows about the questions set. In order to be prepared to pass such examinations the student needs such practice at frequent opportunities to develop through written work his powers of self-expression. Obviously this requires both time and labor on the part of teacher as well as student, but how else shall the student get training in one of the fundamentals of education? The tests devised by Mr. Rich, and by others, doubtless demand careful thinking, but it may be questioned whether they afford that opportunity for self-expression which the older type of test afforded. To underscore a dozen answers to as many questions may demand the ability to think straight but it does not, in the judgment of the reviewer, provide much if any opportunity for that self-expression which the student must develop if he is to meet successfully the standards set for admission to college.

It may also be debated whether it is better pedagogy to place before the candidate printed answers, one of which is known to be correct, or to ask questions which must be answered solely from the candidate's knowledge, without the possibility of suggestion which may lie in a list of answers.

For variety's sake and for the purpose of approaching the matter of testing attainment from a new angle, the occasional use of such tests as those above indicated may be recommended, but the reviewer would be loth to base a series of marks upon the data derived solely from such a set of tests. C. H. STONE

Junior Science. JOHN C. HESSLER, Ph.D., Pa. Benj. H. Sanborn & Co. New York. 1923. xvii + 533 pp. 13 × 19 cm. $1.60.

In his preface the author has taken the viewpoint that while every child uses in an empirical way the facts of science, relatively few children leave school with these facts clarified and ex-

plained in such a way as to satisfy their natural curiosity or interest. Particularly is this so where science courses are offered only in the later high-school years. He has therefore adapted this book to the needs of those too young to leave school but not too young to ask continually the questions, "Why?" and "How?" with an interest as eager as it is new, and has fitted both the treatment of the subject and his style of expression to pupils of junior high-school grades.

Believing that, at the age for which he writes, children have a natural interest in scientific phenomena, and need not so much *to be taught* as *to learn*, the author introduces his topics as nearly as possible in the form of questions such as they would ask, and then, by simple explanation, illustration, or description of experiment, goes on to give suitable answers. At the close of the chapters, preceding brief summaries, are usually a few practical exercises calling for application of what has just been discussed.

The greatest difficulty confronting the writer of a general science text is to find for it a coherent plan, which will give the impression of unity rather than of a smattering of unrelated facts. In all probability no book has yet entirely overcome this defect. Prof. Hessler, after a brief introduction, divides his book into the following six more or less comprehensive units: The Atmosphere and Its Relation to Man, Matter and Energy in Earth and Sky, Science in the Household, How We Use Nature's Forces, Living Things and Their Relation to Us, Our Bodies and How to Care for Them.

Of the forty chapters in the book six are distinctly chemical, with titles as follows: Fire, Oxygen, Carbon and Carbon Dioxide, Substances, Minerals and Metals, Acids and Alkalies. The chapter entitled "Substances" takes up chemical and physical changes, element, compound and mixture, hydrogen, electrolysis of water and its synthesis from the products, salt and crystallization, sulfur and phosphorus in their various forms; that on "Minerals and Metals" gives a brief idea of the occurrence and the smelting of ores, together with short paragraphs on coal, building stones, bricks, mortar and concrete.

In addition, there are scattered items of chemical information under other headings, such as chlorination of water, hard waters and boiler scale under "Water Supply;" action of acids and bases upon cotton and wool, and soap-making under "Washing and Cleaning;" action of yeast and of baking powder under "Cooking and Baking;" glass-making and the manufacture and use of illuminating gas under "Light in the Home;" and sugar refining and action of legumes on nitrogen under "Plants of Use to Man." The various classes of foods are discussed in an appropriate chapter, with reference to the elements contained in each class; also the processes of oxidizing them to set free energy and of storing energy through starch and sugar formation in leaves are simply outlined.

Throughout the book the writer keeps constantly in mind the age and interests of his readers. He presents ideas in the concrete rather than the abstract, leaving mathematics, symbolism, writing of equations and statement of laws for a more advanced course. Knowing from long experience as a teacher the aversion of the juvenile mind for anything requiring painstaking accuracy, the reviewer is inclined to agree with the author upon this method as the one best designed to stimulate rather than to destroy the recently awakened interest in natural phenomena.

A loose-leaf laboratory manual containing fifty simple experiments, very few of which involve measurements, has been published to accompany the textbook. CARLETON E. PRESTON

Chart Showing the Chemical Relationships in the Mineral Kingdom. PALMER COSSLETT PUTNAM, M.S. J. Wiley and Sons, New York, 1925. 17 × 26 cm. 31 pp. $3.00.

This unique volume comprises 12 pages of text, a 9-page alphabetical list of 1611 minerals, another 9-page list of the same minerals arranged numerically, and a linen-backed chart 49 × 94 cm.

The three-fold purpose of the chart is best explained by the opening paragraph: "(A) To serve as a ready reference to the man who would know quickly, whether for an economic or a scientific purpose, the answer to such questions as: 'How many and what are the minerals containing germanium, and what are their compositions?'; or, 'Does silver occur with oxygen in any mineral?'; or, 'Do phosphides or silicides occur as minerals?'; (B) To serve as an aid in Determinative Mineralogy, especially in the case of rare minerals, where either the small amount of the unknown substance, or the lack of laboratory facilities (as when in the field), precludes the possibility of making more than a few specific tests. It may also serve as a complement to microchemical methods in the laboratory, and as a reminder to verify the presence or absence of minute quantities of certain interesting replacing elements; (C) To form a mechanical stimulus to speculation upon the chemistry of the earth, by affording upon one sheet a statistical survey of the affinities and the antipathies which hold sway in the mineral kingdom."

The right- and left-hand vertical margins of the chart contain the 54 "dominant electro-positive constituents of a mineral" and those elements "which occur uncombined but in mineral form." The top and bottom horizontal margins contain the 92 "electro-positive minor constituents," the "electro-negative constituents," the common electro-negative radicals, the water molecule, three of the unknown elements, and the "native elements."

Examples are given to show how to use the chart. Briefly, the "box" corresponding to the marginal dominant and minor constituents contains the numbers assigned to all of the minerals

containing these constituents. Reference to the numerical list gives the names of the minerals and, tracing horizontally in the chart, gives the numbers of the associated minerals.

Probable errors in the chart are discussed under the heads—original data, interpretation of data, and transcription of data. The lists of minerals were not examined by the reviewer for errors. The text contains "elecro" for "electro" on page 3. The most serious criticism is that the numbers in the chart are so small they almost need a magnifying glass to be read, but it is evident that lafger type here would have meant a chart of unwieldy size.

Every mineralogist and every chemist will probably want a copy of this book for reference.

W. SEGERBLOM

A School Chemistry. O. J. FLECKER, B.Sc., Oxford at the Clarenden Press. 1924. viii + 238 pages. Illustrated. 19 × 12.5 cm. $1.20.

Flecker's School Chemistry puts beginners' chemistry upon a strictly experimental basis, since directions for performing 112 experiments constitute the greater part of the work. The author has seen fit to include a discussion of certain laws and theories. These are sandwiched in between the directions for performing the experiments.

A teacher who desires to make the pupil's laboratory work the point of departure of his course and who approves of a book with rather more in the way of thought-directing suggestions than may be found in the usual laboratory manual will probably find this book to his liking.

The content of the course described is not strikingly different from that which may be found in any good American text, and the author acknowledges his indebtedness to one of our best known American textbook writers, now deceased, whose books are noted for their rigorous development of chemical theory.

This book is printed upon a good quality of unglazed paper and the illustrations are all line drawings of such a character that they can be copied by the pupils into their reports.

S. WALTER HOYT

Other Publications Received

Advancing the Frontier of Human Knowledge, is the title of the 28 page booklet published by the Johns Hopkins half century committee. It is "a study of the source of truth and wealth, and of the contributions made to the progress of man by education and research." A university is defined as "an organized and continuing body of men associated together, after due training for a threefold task: (1) to deal at first hand with the sources of knowledge, to seek the truth and so far as possible enrich man's store of it; (2) to impart such knowledge and the methods by which it may be further extended to students at the final and highest stages of their preparation for their own active professional careers; (3) to inspire the men thus trained to serve mankind.

It discusses briefly the origin, nature, importance and the financing of universities. There is a list of twenty-five outstanding discoveries in science with their discoverers and "fifty names which will be forever associated with the cause of education."

D. C. L.

Humanism and Science in the Cathedral of Learning. University of Pittsburgh Bulletin. 15 × 22.5 cm. 15 pp. An address delivered at the Charter Day exercises, University of Pittsburgh, Feb. 27, 1925, by John Duncan Spaeth, Ph.D., Litt.D.

Proposed Syllabus of Chemistry for the Secondary Schools of New York State. The Chemistry Teachers' Club of N. Y. C.

Board of Education—Report of an Enquiry into the Conditions Affecting the Teaching of Science in Secondary Schools for Boys in England. H. M. Stationery Office, London. 1925. 28 pp. 3d. net.

A Description of the Science Laboratories of the Lincoln School of Teachers' College. EARL R. GLENN, CHARLES W. FINLEY AND OTIS W. CALDWELL. Lincoln School of Teachers' College, New York City. 1925. 39 pp.

On the Encouragement of Fundamental Research. National Union Scientific Workers. London. 1924. 23 pp. 6d. net.

A Few Minutes with the Business Manager

AMERICAN CHEMICAL SOCIETY
OFFICE OF THE PRESIDENT

JAMES F. NORRIS
PRESIDENT

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE 39, MASS.

April 28, 1925

Mr. Erle M. Billings,
Eastman Kodak Company,
Rochester, New York

DEAR MR. BILLINGS:

I was very much pleased when I learned that you were planning to send a copy of the "Journal of Chemical Education" to every teacher who is a member of the American Chemical Society.

Those who have been watching the growing interest in the work of the Division of Chemical Education feel confident that the publication issued under the sponsorship of the Division will continue to grow in value and usefulness. The editors have formulated practical plans for the future that will put the Journal in a high position among publications of its kind.

Everyone associated with the teaching of chemistry should be glad to support the praiseworthy effort being made to develop within and without the American Chemical Society an increased appreciation of the work of the teacher and an added interest in his problems.

I want to congratulate those who have done so much for the Journal—editors, contributors, and others—on the rapid increase in the number of subscribers. A study of the copies about to be sent out will lead many to join those who have already decided to do their part in helping along the good work. The Journal speaks for itself. Many will subscribe because they feel that they need what can be obtained from it.

Very truly yours,

JAMES F. NORRIS, *President.*

JUST A FEW EXCERPTS FROM HERE AND THERE

"I am convinced that this Journal is destined to play a very important part in the Chemical Education which is ever becoming more important in our general educational system."

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4 and 18